(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 December 2003 (04.12.2003)

PCT

(10) International Publication Number
WO 03/100941 A1

(51) International Patent Classification⁷: H02J 7/00, H02G 3/00, H02J 3/00, G06F 7/00

(21) International Application Number: PCT/US03/16205

(22) International Filing Date: 22 May 2003 (22.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/382,378 22 May 2002 (22.05.2002) US

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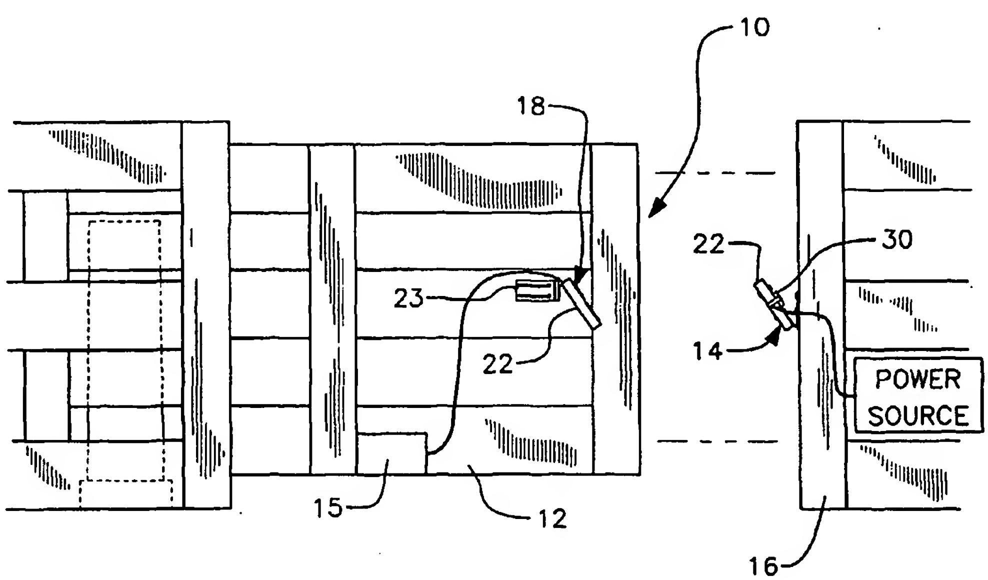
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: RECHARGING SYSTEM FOR A REMOTE CAPACITIVE SENSING APPARATUS



(57) Abstract: A charging system (10) for recharging a remote control module batteries (15) includes electrical contact pads (14) and (18). The first contact pad (14) includes a deicing circuit (28), and a charge enabling switch (36), and is mounted on a post or door frame which engages a sliding gate (12). The second contact pad (18) is connected to the remote control module (15), and is mounted on a sliding gate (12). A charge-enabling switch (38) is operative to cause a charge current to flow from a power source (32) to the remote control module batteries (15) through the first and second pads (14) and (18), when the first and second pads (14) and (18) are in electrical communication.

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RECHARGING SYSTEM FOR A REMOTE CAPACITIVE SENSING APPARATUS

RELATED APPLICATION

This application claims priority of United States Provisional Patent Application Serial No. 60/382,378 filed May 22, 2002, which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to recharging systems and more particularly to recharging systems for use with remote control devices incorporated into object detection systems that utilize capacitive sensing techniques.

BACKGROUND OF THE INVENTION

It is common knowledge to sense the presence of an object using capacitive sensing techniques. Illustratively, an oscillator is operative to deliver a pulsed signal to a sensing element wherein the sensing element provides one of the plates of a capacitor that generates an electromagnetic field. When a grounded object approaches the field; it serves as the second plate of the capacitor whereby the capacitance that is formed between the sensing element and the grounded object varies with the distance between the same. Such a capacitive presence sensing apparatus is disclosed in U.S. Patent No. 5,337,034 to Simon. The apparatus therein has been used with various devices such as parking gate arms, lift gates and slide gates, and the like. When used on lift gates and slide gates, the capacitive sensors are connected to remote control modules. The remote control modules are typically mounted to the movable portions of the gates and comprise wireless communication circuitry and an internal power source such as a rechargeable battery.

To recharge the batteries of the remote control modules, complementary charging contacts are mounted to the movable portion of the gate and to a structure adjacent to the movable portion of the gate such that

charging power can be delivered to the batteries when the gate is closed. However, under certain conditions it is possible for snow and ice to collect on these charging contacts thereby rendering the charging system ineffective.

Accordingly, a charging system utilizing a pair of complementary contacts and a heat dissipating element having a heat sink has been developed. Additionally, the charging system includes a power-saving mode for increasing the useful life of the battery.

SUMMARY OF THE INVENTION

The present invention provides a recharging system for a remote control module wherein the charging system includes elements that allow the system to maintain its charging capability in inclement weather such as snow and ice, and includes a safety mechanism to prevent inadvertent shock or injury to the user.

The charging system provides complementary electrical contact pads wherein a first pad is in electrical communication with a power source and a second pad is in electrical communication with a rechargeable battery.

A deicing circuitry is disposed on the first pad that is connected to the power source such that the necessary current needed to energize the deicing circuitry can be obtained readily from a substantially unlimited source.

A deicing switch is provided in electrical communication with the deicing circuitry and the power source. The deicing switch is operative to energize the deicing circuitry at or below a predetermined temperature threshold.

A charge enabling switch is disposed on the first pad and is operative to permit a charge current to flow from the power source to the rechargeable battery through the first and second pads when the first and second pads are in electrical communication.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood by reference to the following detailed description in conjunction with the accompanying drawings

in which the like reference characters refer to like parts throughout the several views and in which:

Figure 1 illustrates a perspective view of a charging system for a remote control apparatus wherein the remote control apparatus is mounted to a sliding gate;

Figure 2 illustrates a schematic view of the supply and switch side of the recharging system as according to the invention;

Figure 3 illustrates an enlarged view of the contact pads of the recharging system being brought into electrical communication by closing the sliding gate of Figure 1;

Figure 4 exemplifies an embodiment of a contact pad which may be used on the load side of the recharging system;

Figure 5 exemplifies a contact pad which may be used on the supply side of the recharging system;

Figure 6 illustrates an exploded view of a remote control device which includes the rechargeable battery and a malfunction indicator enabling switch as according to the invention;

Figure 7 illustrates an embodiment of the recharging system incorporating a magnetic proximity switch as used with a conventional garage door; and

Figure 8 illustrates an enlarged view of the spindle portion of the garage door assembly wherein the spindle houses the magnetic proximity switch sensor.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a recharging system for use with a remote control module having a rechargeable battery and more particularly to a remote control module mounted on a movable object such as a sliding or lift gate. The inventive charging system provides additional features for enabling effective charging during inclement weather when snow and ice may form on various elements of the charging system to degrade the system's performance.

Additional features are added to protect against shock or injury to those coming into contact with the charging system inadvertently.

As shown in Figure 1, the charging system 10 includes a pair of complementary electrical contact pads 14 and 18. The first contact pad 18 includes a deicing circuit and a charge enabling switch which prevents inadvertent shock or injury to those who may come into contact with the exposed pad. The second pad 18 is mounted to a movable object such as a sliding gate 12 or door while the first pad 14 is mounted to a fixed member such as a post or door frame which engages the sliding gate 12 when the gate 12 is moved to a closed position. The second pad 18 is connected to a remote control module 15.

Each contact pad includes a nonconductive support portion 22 disposed with at least one electrical contact. As illustrated in Figure 3, the support portion 22 of the pad 18 is mounted on an outer portion of a resilient strap 20 which may be provided in the form of a V-shaped leaf spring. It is appreciated that other forms of resilient straps known to those skilled in the art may be used that are suitable for the purpose described herein. The strap 20 that supports the second pad 18 is mounted to a bracket 22 that is attached to the gate 12 via a conventional fastening means. The second pad 18 is attached to the resilient strap 20 at one end whereby the second pad 18 is supported thereto in an angled fashion. The first pad 14 is attached to a second resilient strap 20 in a complementary fashion to the second pad 18 such that when the pads abut one another upon the closing of the door 12, the resilient straps 20 become increasingly compressed such that the contact pads 14 and 18 become oriented substantially vertical when the sliding gate 12 is completely closed.

Preferably, the nonconductive support portion of each pad is formed of an extrudate material which may illustratively include Delron, nylon or polyethylene. Other nonconductive materials that may be used for the nonconductive support portion 22 may illustratively include plastic, rubber or wood.

As shown in Figures 4 and 5, the first 14 and second 18 pads include conductive members 24 and 26 respectively arranged on the nonconductive support portion 22 in a complementary manner to facilitate electrical communication between the conductive members 24 and 26 when the pads are engaged. As illustrated in Figure 5, the contact members 24 of the first pad appear as bolts while the contact members 26 of the second pad appear as elongated strips. The contact members 24 and 26 may be formed in various structural shapes and of any conductive material suitable for such purpose herein which may illustratively include copper, silver or other conductive metallic material of relatively low impedance. When the sliding gate 12 is closed, the pads 14 and 18 are brought together so that the contact members 24 and 26 slidably engage during the closing of the gate. It is appreciated that because the position of the gate after closure may vary from time to time, the resilient straps 20 are deformable to accommodate contact through a range of closure positions. It is further appreciated that various pad mounting and contact members arrangements may be resorted to by those skilled in the art without departing from the scope of the invention.

Referring again to Figure 1, the first pad 14 includes a deicing circuit 28 having at least one power resistor 30 mounted to a backside of the first pad 14. The power resistor 30 is connected to the contact members 24 of the first pad 14. Electrical power is supplied to the deicing circuit 28 from a power source 32 via an electrical conductor.

Referring now to Figure 2, the at least one power resistor 30 is associated with a heat sink 33 (not shown) and is connected to a deicing switch 36. The deicing switch 36 is operative to enable the deicing circuitry for the purpose of melting ice or snow that becomes disposed on the contact pads during inclement weather. Preferably, the deicing switch is operative to energize the deicing circuitry 28 automatically at or below a predetermined temperature threshold. Accordingly, the deicing switch 36 may be provided in the form of a temperature-sensing device such as thermostat or thermistor. If used, the thermostat may be of any type such as a bimetal thermostat that acts

to switch power to the power resistor 30 and heat sink when the temperature is at or below a predetermined threshold such as 34° Fahrenheit.

Referring now to Figure 3, the heat sink 33 generates heat when a supply voltage such as 24 volts is applied to the power resistor 30. In this manner, heat is dissipated through the contact members 24 which in turn will dissipate heat through to the contact members 26 of the second pad 18 when the pads 14 and 18 are engaged.

Electrical power is supplied to the first pad 14 from a power source 32. The power source 32 supplies a charging voltage to the contact members 24 that is higher than the voltage of the deicing circuit 28.

In order to prevent persons from inadvertent shock or injury from contact with the first pad 14, a charge-enabling switch 38 is disposed at the first pad 14. The charge-enabling switch 38 is operative to cause a charge current to flow from the power source to the rechargeable battery through the first and second pads when the first and second pads are in electrical communication. The charge-enabling switch may be provided in the form of a magnetic proximity switch, a momentary contact switch, an infrared detection switch, or the like. If a magnetic proximity switch is used, then the second pad 18 will be disposed with a magnet 40 as a means of activating the magnetic proximity switch to cause the flow of charge current from the power source to the rechargeable battery.

Thus, when the gate is open and the contact members separate, the charge enabling switch 38 will become disabled and the flow of current will be inhibited. However, when the gate is subsequently closed and the contacts are brought into engagement, the charge-enabling switch is tripped to close the circuit and energize the contact members with the charging current. In this fashion, there is provided a safe, reliable charging system that is not compromised by the effects of snow and ice. It is appreciated that the above described circuitry associated with the power side of the recharging system 10 may be associated with the load side without exceeding the scope of the invention.

Referring now to Figure 6, a remote control module 15 is illustrated having a housing 48 that includes a front panel 49. The housing 48 may also include a front panel cover 50 for protecting the front panel 49 from environmental exposure or vandalism. The front panel 49 of the remote control module 15 includes at least one malfunction indicator 52. The remote control module 48 includes electronic circuitry for generating and delivering control signals to some peripheral devices associated with the sliding gate 12 system.

Part of the electronic circuitry contained therein includes a diagnostic circuit that is in communication with the malfunction indicator 52. The malfunction indicator 52 may illustratively be provided in the form of a seven segment display LED or a liquid crystal diode device or the like for providing diagnostic numbers which correspond to various conditions of the system associated with the remote control module 48. When there is a system malfunction, a service person will remove the front panel cover 50 of the remote control module 48 to view the malfunction indicator 52 to determine the status of the equipment.

The malfunction indicator 52 may require a relatively large amount of electrical power that may compromise the utility of the remote control module which depends on a rechargeable battery for its power. To address this concern, the recharging system 10 preferably includes a malfunction indicator enabling switch 54 which is operative to power down the malfunction indicator display when the front panel cover plate is disposed over the front panel 49 of the remote control module 48. When the front panel cover 50 is removed from the remote control module 48, the malfunction indicator enabling switch 54 closes the circuit to power the malfunction indicator 52. Replacing the front panel cover 50 opens the malfunction indicator enabling switch 54 to disable the malfunction indicator as a means of conserving the power of the rechargeable battery.

Referring now to Figures 7 and 8, there is illustrated a type of charge enabling switch 38 which may be used with a remote control module 15 mounted on a conventional garage door 60 that is guided along a track 62 by

wheels 80 mounted to extend beyond the edges of the door 60. It has been found that incorporating a magnetic switch in a wheel assembly provides an excellent mounting place for the switch and allows for the mounting of the magnet 70 on the exterior of the guide track 62 to trip the switch when the switch passes through the field of the magnet 70. In this manner, the recharging system 10 may be enabled when the garage door is moved to the closed position.

Each wheel assembly includes a wheel 64 mounted on one end of a spindle 66. The center of the spindle 66 at the wheel end is bored and a charge enabling switch sensor 68 is mounted axially therein. The switch sensor 68 is mounted at the wheel end of the bore in the spindle 66 with a conventional fastening means or adhesive suitable for such purpose. The wheel assembly is then inserted into the door 60 and the magnets 70 are placed on the track 62 corresponding to the position where it is desired to send a signal indicating the passage of the wheel 64 and door 60. The switch sensor 68 is placed in electrical communication with the remote control module 15 via electrical conductors to facilitate a charging of the rechargeable batteries disposed in the remote control module 15 as according to the invention.

From the foregoing it can be seen that the present invention provides a charging system for a remote control module wherein the charging system includes deicing and charge enabling circuitry. Although the invention has been described with respect to certain illustrations and embodiments thereof, many modifications thereto may become apparent to one skilled in the art without deviation from the spirit of the invention as defined by the scope of the appended claims.

We claim:

CLAIMS

1. A charging system comprising:

complementary electrical contact pads wherein a first pad is in electrical communication with a power source and a second pad is in electrical communication with a rechargeable battery;

a deicing circuitry disposed on the first pad;

a deicing switch in electrical communication with the deicing circuitry and the power source, said deicing switch operative to energize the deicing circuitry at or below a predetermined temperature threshold; and

a charge enabling switch disposed at the first pad operative to permit a charge current to flow from the power source to the rechargeable battery via the first and second pads when the first and second pads are in electrical communication.

2. The charging system of claim 1 wherein the deicing circuitry comprises a power resistor with heat sink.

3. The charging system of claim 1 wherein the deicing circuitry comprises a coil with heat sink.

4. The charging system of claim 1 wherein the deicing switch is a thermostat.

5. The charging system of claim 1 wherein the deicing switch is a thermistor.

6. The charging system of claim 1 wherein the predetermined temperature threshold is 0° Celsius.

7. The charging system of claim 1 wherein the charge enabling switch is a magnetic proximity switch.

8. The charging system of claim 1 wherein the second pad includes a magnet operative to energize the magnetic proximity switch when the complementary electrical contact pads are in electrical communication.

9. A charging system for recharging a remote control module comprising:

complementary electrical contact pads wherein a first pad is in electrical communication with a power source and a second pad is in electrical communication with a rechargeable battery disposed in the remote control module;

a deicing circuitry disposed on the first pad;

a deicing switch in electrical communication with the deicing circuitry and the power source, said deicing switch operative to energize the deicing circuitry at or below a predetermined temperature threshold; and

a charge enabling switch disposed at the first pad operative to permit a charge current to flow from the power source to the rechargeable battery via the first and second pads when the first and second pads are in electrical communication.

10. A charging system for recharging a remote control module wherein the remote control module includes a malfunction indicator circuit and is disposed on a movable object, said charging system comprising:

complementary electrical contact pads wherein a second pad is in electrical communication with a rechargeable battery disposed in the remote control module, and wherein a first pad is disposed on a stationary object and the first pad is in electrical communication with a power source;

a deicing circuitry disposed on the first pad;

a deicing switch in electrical communication with the deicing circuitry and the power source, said deicing switch operative to energize the deicing circuitry at or below a predetermined temperature threshold;

a charge enabling switch disposed at the first pad operative to permit a charge current to flow from the power source to the rechargeable battery via the first and second pads when the first and second pads are in electrical communication; and

an indicator enabling switch disposed on the remote control module wherein said indicator enabling switch is in electrical communication with the rechargeable battery and at least one malfunction indicator.

11. The charging system of claim 10 further comprising a cover plate disposed over the indicator enabling switch such that removing said cover plate energizes the at least one malfunction indicator.

12. The charging system of claim 10 wherein the indicator enabling switch is a SPST switch.

13. The charging system of claim 10 wherein the movable object is a rail mounted sliding gate.

14. The charging system of claim 13 wherein the charge enabling switch is disposed on the rail such that charge current is permitted to flow when the sliding gate is in the closed position.

15. The charging system of claim 14 wherein the charge enabling switch is a magnetic proximity switch.

16. The charging system of claim 15 wherein the sliding gate is disposed with a magnet operative to energize the magnetic proximity switch.

17. The charging system of claim 1 further comprising a voltage sensing circuit.

18. The charging system of claim 17 wherein the voltage sensing circuit is operative to sense the voltage level of the rechargeable battery and disables the charge enabling switch when a predetermined voltage level is reached.

19. A remote control module having a housing with a rechargeable battery disposed therein, said remote control module comprising:

at least one malfunction indicator disposed on the housing;

a cover plate detachably fixed to the housing such that the cover plate is disposed over the at least one malfunction indicator; and

an indicator enabling switch disposed on the housing wherein said indicator enabling switch is in electrical communication with the rechargeable battery and the at least one malfunction indicator such that removing said cover plate energizes the at least one malfunction indicator.

20. The remote control module of claim 19 wherein said housing is disposed on a movable object.

21. A charge enabling switch for use with a recharging system, said recharging system being operative to recharge a battery disposed within a remote control module wherein said remote control module is disposed on a garage door that includes a guide wheel assembly that move along a guide track, said switch comprising:

a magnetic sensor switch disposed within a spindle the guide wheel assembly in communication with the recharging system and the remote control module; and

a magnet disposed on the guide track operative to enable the magnetic sensor switch when the garage door is moved to close whereby the recharging system is enabled to charge the battery.

FIG. 1

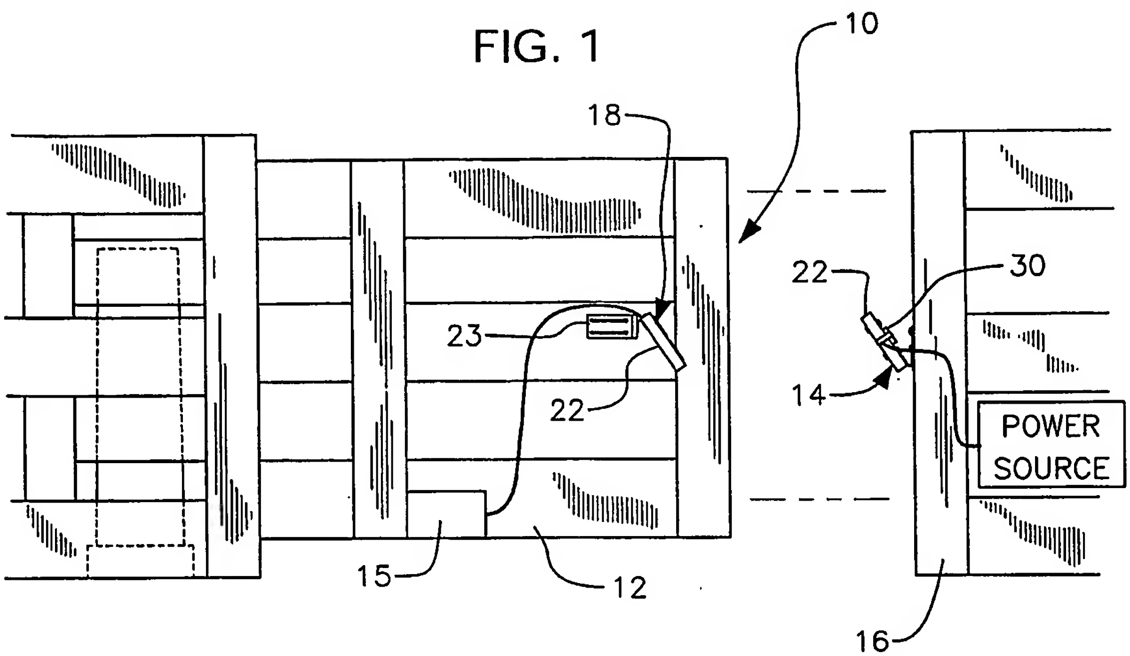


FIG. 6

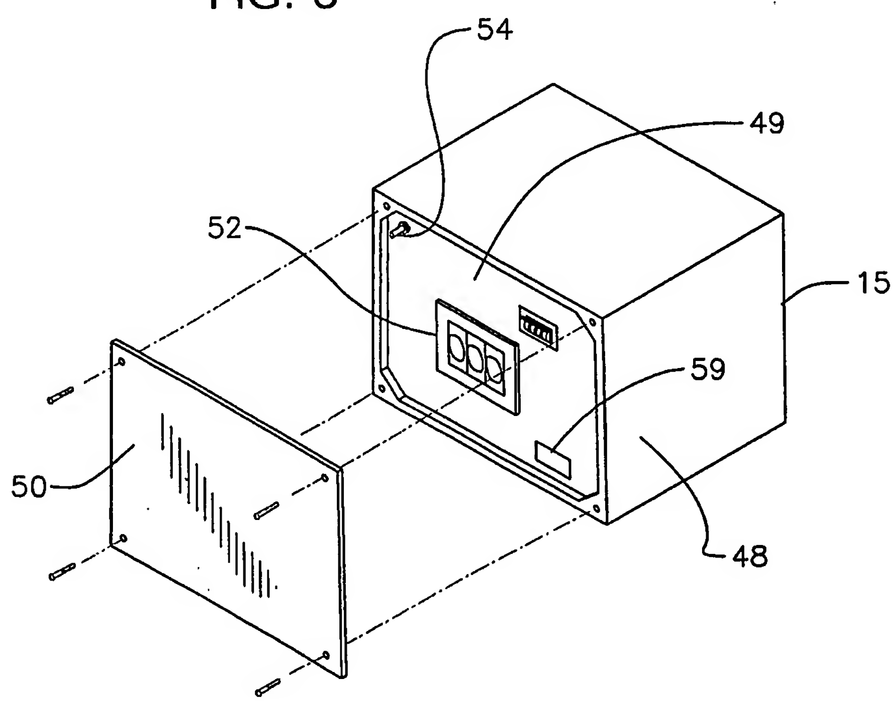


FIG. 2

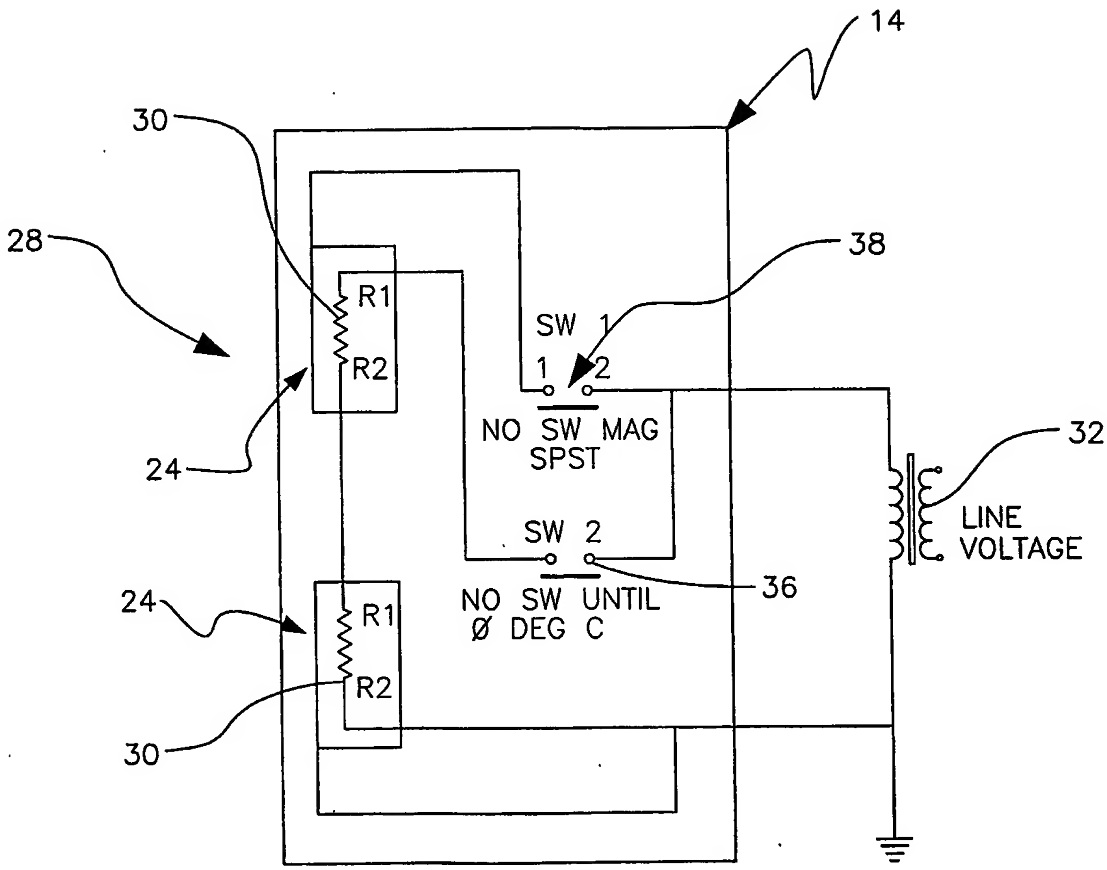

14
30
28
38
R1
R2
SW 1
1 2
NO SW MAG
SPST
24
32
LINE
VOLTAGE
SW 2
36
24
NO SW UNTIL
Ø DEG C
R1
R2
30

FIG. 3

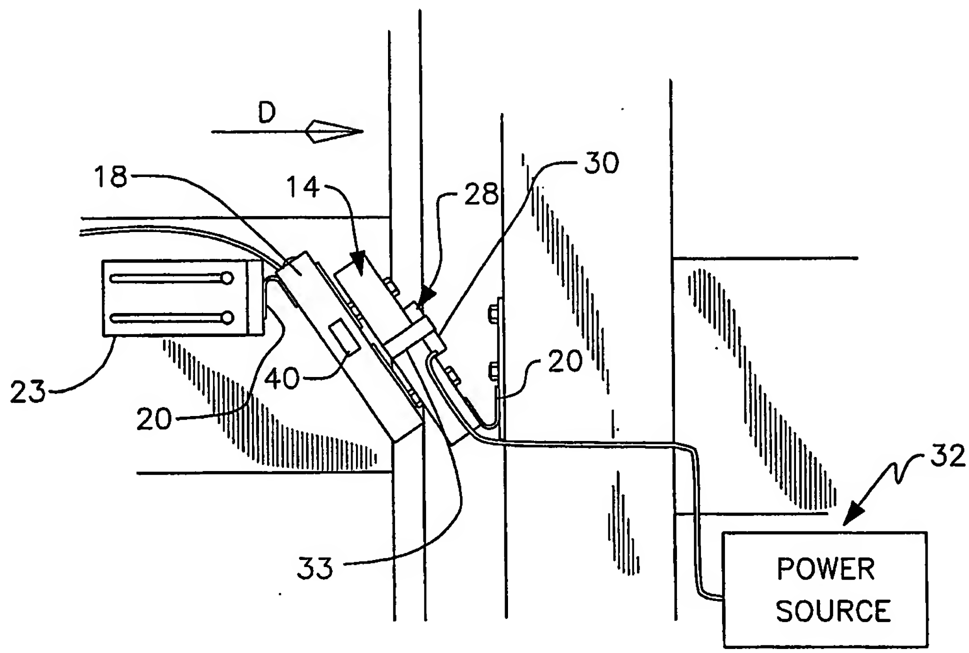


FIG. 4

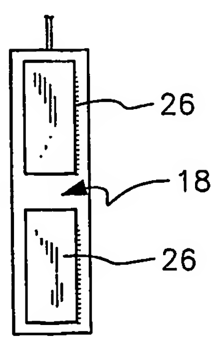


FIG. 5

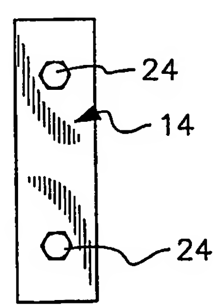


FIG. 7

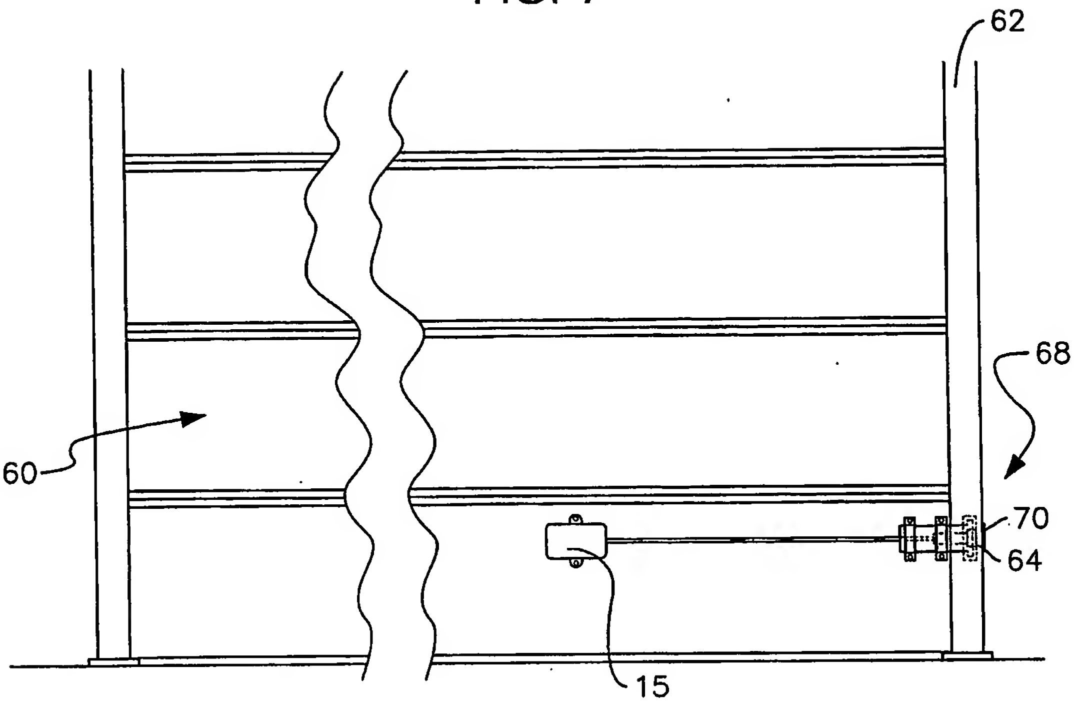
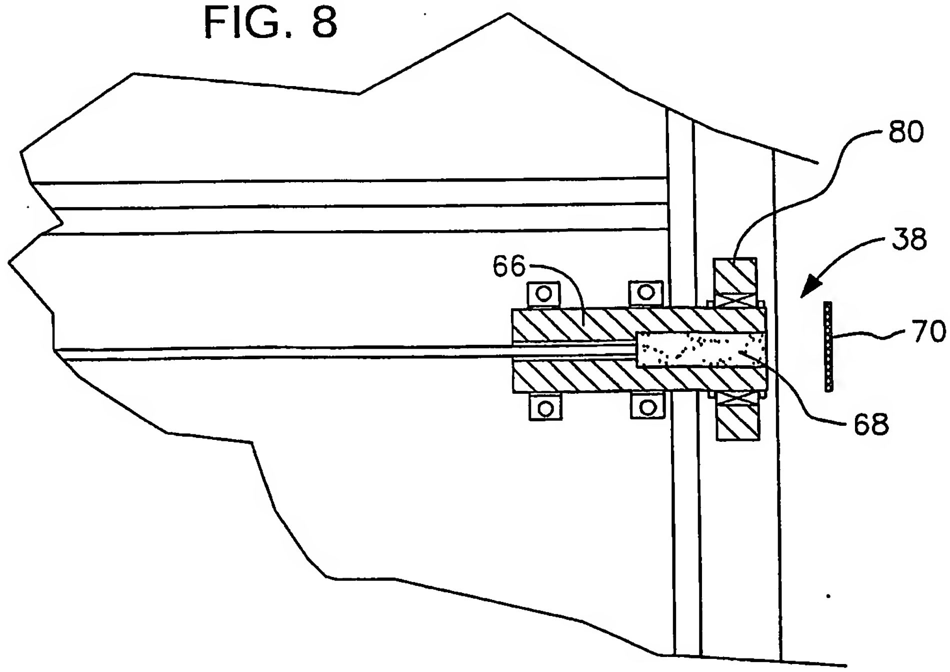


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/16205

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H02J 7/00; H02G 3/00; H02J 3/00; G06F 7/00
US CL : 320/104; 307/9.1, 10.1; 219/121.16, 121.65; 340/441, 670, 671
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 320/104; 307/9.1, 10.1; 219/121.16, 121.65; 340/441, 670, 671

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, STN

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,013,994 A (TAKATSUKA) 07 May 1991.	NONE
A	US 4,862,055 A (MARUYAMA et al.) 29 August 1989.	NONE

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 JULY 2003	10 SEP 2003

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	PIA TIBBITS Diane Smith for
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1680

completed processing of another image frame and the data is ready for processing by the feature processing module (FIGURE 16). Moreover, if desired, the write diagnostics step 262, which is performed by CPU 125 (FIGURE 15), can store within memory one or more messages regarding how the processing of the previous frame data progressed. The video processing loop 250 then preferably continues back to the get next frame step 252.

Turning to FIGURE 23, a simplified block diagram is provided of an embodiment of an initialization procedure for the ping-pong system of FIGURE 22. In an embodiment, the ping-pong initialization procedure 264 includes an initialize ping-pong addresses module 265, a capture video buffer module 266, a capture frame module 267, an initiate video references module 268, a process video module 269, a process frame module 270, and a retrieve FPGA data module 271.

FIGURE 24 provides a simplified block diagram of the ping-pong process loop 272 for the ping-pong system of FIGURE 22. The top of the loop 272 shows the CPU activity while the bottom shows the FPGA activity (not in time scale), with the associated serial I/O and CSR messaging.

FIGURES 25 and 26 illustrate the details of the ping/pong activity (initialization & video loop) in an alternative embodiment having an automatic contrast circuit (ACC). The ACC can be used to improve system detection performance due to slowly changing lighting conditions. The ACC does this by changing the video gain in response to image characteristic criteria and time dynamic criteria. The ACC maximizes gain while preventing too much image white saturation. After a gain change, the video system is reinitialized.

The ACC, when enabled by user input, functions during initialization to find the best starting gain by iterating and testing the image result. When a gain is found which satisfies established criteria, iterating stops, and the process continues to the video loop with the selected gain. The ACC also functions at the beginning of the video loop, but does not iterate to fine a satisfactory gain. Only a single gain change is performed in the loop per frame. The gain change and consequent video system initialization take

a much shorter time than a frame time (100 ms). The decision to require a gain change in the video loop is controlled by criteria calculated in the detection and control portion of the CPU activity. The criteria can include aging, zone activity, and long and short time-constant filters.

FIGURE 27 provides a simplified block diagram of the zone initialization sequence 240 for the system initialization of FIGURE 17. The zone initialization sequence 240 results in the building of zones in real world coordinates, generating control zone submasks and constructing control zone masks. FIGURE 28 provides a simplified block diagram of the threshold tables initialization sequence 238 for the system initialization of FIGURE 17. The threshold tables initialization sequence 238 result in the initialization of camera intrinsic parameters, the resolution model, and the object model.

Turning to FIGURE 29 (and referencing FIGURES 48 and 49), a simplified block diagram is provided of the image processing module for the processing system of FIGURE 16 which includes an edge detector 301. The edge detector 301 preferably includes a modified Sobel operator module 302, a positive difference module 304, a threshold module 306, an erode module 308, and a label I module 310.

In an embodiment, the modified Sobel operator module 302 receives current (B) image input 312 and generates the edge image (GEB) 314 from the current input image. A reference image (GER) 316, initialized in the CPU, is subtracted from the current edge image in the positive difference operator module 304, where negative values are set to zero. The grey-level edge image is thresholded 306, eroded 308, and labeled 310. The output of the label I operator 310 is a 16-bit labeled image 318, an equivalence table 320, and counts of the number of labels used 322 and the number of entries in the equivalence table. Counts of the number of set pixels in the binary input 324 and output 326 of the erode operator 308 are also output to the CPU, completing the edge image processing.

Label I operator 310 is used in each thread of the image processing. Label I 310 is the first part of a two step process used to produce the labeling of the connected components of the binary input. Label I 310 passes a 2x2 kernel over the binary input image beginning with the upper left of the image. The elements of the kernel are identified as follows:

B C

A X

If the binary pixel in X is zero, the output is zero. If X is set, the labels B, A, C are scanned in that order. If all of B, A, C are non-zero, the next value of a label counter is output at X and the counter is incremented. If any B, A, C are non-zero, the label operator is the value of the first non-zero label. If more than one of B, A, C is non-zero, the first non-zero value is output. If any of the remaining non-zero labels is different from the output value, the output value and the different value are written to an equivalence table.

Turning to FIGURE 30 (and referencing FIGURES 48 and 49), a simplified block diagram of the image processing module for the processing system of FIGURE 16, having a motion detector that uses regions 340. The system 340 preferably includes positive difference modules 342 and 344, threshold modules 346 and 348, and dilate modules 350 and 352 for both the current (B) input image (n) and previous (A) image (n-1) respectively. The output is passed to the inclusive OR module 354, erode module 356, and Label I module 358.

The positive difference of the current grey-level input image (B) 360 and the previous image (A) 362 is thresholded 346 and 348 and dilated 350 and 352, as well as the positive difference of A and B 342 and 344. The results are inclusively ORed 354. The resulting binary image is labeled as in the edge case (FIGURE 29), and the results are passed to the CPU.

The grey-level edge image is thresholded, eroded 356, and labeled 358. The output of the label I operator 358 is a 16-bit labeled image 364, an equivalence table 366,

and counts of the number of labels used 368 and the number of entries in the equivalence table. Counts of the number of set pixels in the binary input 370 and output 372 of the erode operator 356 are also output to the CPU, completing the motion detector image processing using regions.

Label I operator 358 is used in each thread of the image processing. Label I 358 is the first part of a two step process used to produce the labeling of the connected components of the binary input. Label I 358 passes a 2x2 kernel over the binary input image beginning with the upper left of the image. The elements of the kernel are identified as follows:

B	C
A	X

If the binary pixel in X is zero, the output is zero. If X is set, the labels B, A, C are scanned in that order. If all of B, A, C are non-zero, the next value of a label counter is output at X and the counter is incremented. If any B, A, C are non-zero, the label operator is the value of the first non-zero label. If more than one of B, A, C is non-zero, the first non-zero value is output. If any of the remaining non-zero labels is different from the output value, the output value and the different value are written to an equivalence table.

Turning to FIGURE 31 (and referencing FIGURE 48 and 49), a simplified block diagram of the image processing module for the processing system of FIGURE 16, having region analysis for shadow and lightbeam processing. The system 380 preferably includes positive difference modules 382 and 384, threshold modules 386 and 388, and dilate modules 390 and 392 for both the current (B) input image 394 and reference (R) input 396, respectively. The output is passed to the inclusive OR module 396, erode module 400, and Label I module 402. The output of the label I operator 402 is a 16-bit labeled image 404, an equivalence table 406, and counts of the number of labels used 408 and the number of entries in the equivalence table. Counts of the number of set pixels

in the binary input 410 and output 412 of the erode operator 402 are also output to the CPU, completing the motion detector image processing using regions.

The system image processing region analysis detection operation is analogous to the motion detection operation of FIGURE 30 except that instead of using the immediately previous image input A, it uses a previous image called the reference image 396 which is updated on CPU command as a copy of the current input image. The region analysis thread also produces a difference image 414 and a 16-level histogram 416 for CPU use.

Turning to FIGURE 32 (and referencing FIGURES 48 and 49), a simplified block diagram of the image processing module for the processing system of FIGURE 16, having a motion detector that uses edges 420. The system 420 illustrates a selectable alternative motion detection image processing operation similar to the edge detection operation of FIGURE 29, except that it takes the current edge image (GEB) 422 and the previous edge image (GEA) 424 as input to the positive difference module 426. The positive difference of GEB 422 minus GEA 424 is thresholded 428, eroded 430 and labeled 432 as in FIGURES 19, 20, and 21.

The output of the label I operator 432 is a 16-bit labeled image 434, an equivalence table 436, and counts of the number of labels used 438 and the number of entries in the equivalence table. Counts of the number of set pixels in the binary input 440 and output 442 of the erode operator 430 are also output to the CPU, completing the system image processing having a motion detector that uses edges.

Turning to FIGURE 33, a simplified block diagram of the feature processing module 450 for the processing system of FIGURE 16, for calculating presence, motion, frame and region features. The system data processing, calculating all features, is performed in the FPGA to unburden the CPU and achieve the desired processing rate.

The presence (P) or edge feature module 452 and the shadow and lightbeam (SL) or region feature module 458 calculations are quite similar to the point of generating the edge/region score discounts. Moreover, within the P feature 452 and SL feature 458

calculations, the global calculations are very similar to the zone calculations. The zone calculations restrict the spatial range of feature calculations for each zone using the associated zone mask. The results of the P and SL feature calculations are stored in a database (feature tables) for use in detection determination 460.

Frame features 456 are calculated differently than P and SL features. Frame features 456 are not features of objects, but of the input grey level image and the current edge image. Frame statistics are computed in order to draw inferences about conditions of the camera and video system integrity. Frame statistics are also used to condition some detection variables that act as adaptive thresholds. Three fault flags can be set by the calculate frame features module 456: illumination fault flag, obscure fault flag, and ajar fault 462. Each of these faults 462 is determined through associated metrics. The illumination fault is controlled by evaluating the modified Kuiper statistic, the uniform centered mean, and the variance of the grey level input. The obscure and ajar faults use the current and archive edges to detect whether the camera and/or video system have become obscured or knocked ajar.

The system 450 will not update the reference if any motion is detected in any zone. To determine if there is motion in each zone, the labeled edge image counts the number of non-zero pixels in the labeled zone, calculated in the presence P feature module 452. The non-zero pixels become motion pixels, calculated in the motion M feature module 454. The system 450 counts the non-zero pixels in the motion labeled image to verify if the zone motion pixels in each zone is greater than zero (0). The system 450 counts the non-zero pixels in the zone detection mask for accumulation in the count.

Turning to FIGURE 34, a simplified block diagram of the feature generation system 470 of FIGURE 33, having a label module 472, a calculate global presence features module 474 and a calculate zone presence features module 476.

The label module 472 receives presence input in the form of labeled edge image 478, equivalence tables 480, and label and conflict counts 482. The label module

472 resolves pixel labeling conflicts within the region, it replaces labels with region numbers, it makes an area call, renumbering regions with sequential indices, and re-indexes the region again, passing data related to the number of regions and regions image to the calculate global presence features model 474.

The calculate global presence features model 474 uses the regions image 484, the number of regions 486 and current edges (GEB) 488 to create a global feature table. The global feature table is first initialized, regions are labeled as to area, mean grey level intensity, histogram, and centroid. The region is then recalculated for variance of grey level and centroid, listing the features (global, safety,...) of the pixels within the region.

The calculate P feature zones module 476 takes the aforementioned regions image 484, number of regions 486, the current edges (GEB) 488 and creates a zone feature table using zone mask and rectangle 490. The system 470 determines motion in zones by calculating detection in a safety zone, a secondary safety zone, a door zone, a first activation zone, a second activation zone, a first guard zone, and a second guard zone.

Turning to FIGURE 35, a simplified block diagram of the calculate presence (edge) feature system of FIGURE 34, for calculating global presence features module 500.

The global P features are calculated first by initializing the edge counts of the feature table 502. The global extent of the image is calculated in the image first pass module 504. Area, centroid, mean, histogram and edge counts are accumulated and put through the image second pass module 506 where a second central moments and variance is accumulated. The feature table pass module 508 calculates the derived features including the spread, elongation, orientation, and ellipse shape of the region. The calculate region scores module 510 determines door rejection, edge shape suppression, and edge grey level suppression. A score comes from the grey level variance of the region and a discount is applied to the score. After region scores are calculated 510, the next region is looped through the calculations of the feature table pass module 508.

Turning to FIGURE 36, a simplified block diagram of the calculate presence feature system of FIGURE 34, for calculating zone presence features.

The zone presence P features are calculated first by initializing the zone counts of the feature table 522. The global extent of the zone is calculated in the zone first pass module 524. The zone is calculated to determine if pixels are in the selected zone mask. Area, centroid, mean, and histogram are also accumulated and put through the image second pass module 526 where a second central moments and variance is accumulated. The feature table pass module 528 calculates the derived features including the spread, elongation, orientation, and ellipse shape of the region. The calculate region scores module 530 determines door rejection, area proportion suppression, edge shape suppression, and edge grey level suppression. After region scores are calculated 530, the next region is looped through the calculations of the feature table pass module 528.

Turning to FIGURE 37, a simplified block diagram of the feature generation system 540 of FIGURE 33, having a label module, a calculate global shadow and lightbeam (SL) features module, and a calculate shadow and lightbeam zone features module.

The label module 542 receives presence input in the form of labeled edge image 544, equivalence tables 546, and label and conflict counts 548. The label module 542 resolves pixel labeling conflicts within the region, it replaces labels with region numbers, it makes an area call, renumbering regions with sequential indices, and re-indexes the region again, passing data related to the number of regions and regions image to the calculate global presence features model 550.

The calculate global presence features model 550 uses the regions image 552, the number of regions 554 and the current difference image to create a global feature table. The global feature table is first initialized, regions are labeled as to area, mean grey level intensity, histogram, and centroid. The region image is then recalculated for variance of grey level and centroid second movements, listing the shape features of the image within the region.

The calculate SL feature zones module 558 takes the aforementioned regions image 552, number of regions 554, the current edges (GEB) 560 and creates a zone feature table using zone mask and rectangle 562. The system 540 determines motion in zones by calculating detection in a safety zone, a secondary safety zone, a door zone, a first activation zone, a second activation zone, a first guard zone, and a second guard zone.

Turning to FIGURE 38, a simplified block diagram of the calculate shadow and lightbeam region features 570 system of FIGURE 37, for calculating global shadow and lightbeam (SL) features.

The global SL features are calculated first by initializing the edge counts of the feature table 572. The global extent of the image is calculated in the image first pass module 574. Area, centroid, mean, histogram and edge counts are accumulated and put through the image second pass module 576 where a second central moments and variance is accumulated. The feature table pass module 578 calculates the derived features including the spread, elongation, orientation, ellipse shape factor of the region, modified kniper statistic and mapped mean and variance. The calculate region scores module 580 determines the SL score with region suppression from shadow and light beam discount, shape discount, and area discount and with transient suppression. After region scores are calculated 580, the next region is looped through the calculations of the feature table pass module 578.

Turning to FIGURE 39, a simplified block diagram of the calculate shadow and lightbeam region features 590 system of FIGURE 37, for calculating shadow and lightbeam (SL) zone features.

The zone SL features are calculated first by initializing the zone counts of the feature table 592. The global extent of the zone is calculated in the zone first pass module 594. The zone is calculated to determine if pixels or zone rectangle are in the selected zone mask. Area, centroid, mean, and histogram are also accumulated and put through the image second pass module 596 where a second central moments and variance

is accumulated. The feature table pass module 598 calculates the derived features including the spread, elongation, orientation, ellipse shape factor, modified kniper statistic, and mapped means and variance of the region. The calculate region scores module 600 determines the SL score with region suppression from shadow and light beam discount, shape discount, and area discount and with transient suppression. After region scores are calculated 600, the next region is looped through the calculations of the feature table pass module 598.

FIGURE 40 provides a simplified block diagram of a split histogram grey level analysis 700 for the processing system of FIGURE 16, and in particular the feature processing module 214. In an embodiment, the split histogram grey level analysis 700 can be provided to assists in the determination of region features.

FIGURE 41 provides a simplified block diagram of the feature generation system 750 of FIGURE 33, for calculating frame features. The system 750 include a frame analysis initialization module 752, a compute frame statistics module 754, an interpret frame illumination metrics module 756, an interpret obscure metrics module 758, an interpret ajar metrics module 760, and an update FA filter 762.

FIGURE 42 is a simplified block diagram of the information processing module of FIGURE 16, for detecting the presence of an object from features generated. The detection sequence includes an evaluate fault flags module 800, an evaluate reference updates module 802, an automatic adaptive thresholds module 804, an update frame analysis data module 806, and an update motion reference module 808.

FIGURE 43 is a simplified block diagram of the information processing module of FIGURE 16, for evaluating and updating reference images. The evaluate reference updates sequence includes a zones motion detection module 822, an update update counters module 824, a decide standard update module 826, a decide archive update module 828, a decide gain change module 830, and a decide learn-outs module 832.

FIGURE 44 is a simplified block diagram of the information processing

module of FIGURE 16, for changing threshold values relative to changing background values from the field of view. The automatic adaptive thresholds sequence includes an initialize SL thresholds edge threshold 840, a calculate zone statistics module 842, a calculate zone metrics module 844, and an apply metrics module 846.

FIGURE 45 is a simplified block diagram of the information processing module of FIGURE 16, for determining the geometric association of edge and zone data in a detected object. The sequence includes an initialize module 850, an application for each qualified edge region 852, an application regarding initialization for a particular region 854, and a traverse region bounding rectangle module 856. The sequence then continues to FIGURE 46.

FIGURE 46 is a continuation of FIGURE 45 of the simplified block diagram of the information processing module of FIGURE 16, and includes testing region edges to determine zone intersections in detected objects. The sequence includes a test edge region/zone intersection modules 862,864 and a test region/motion/zone intersection module 866.

FIGURE 47 is a continuation of FIGURE 46 of the simplified block diagram of the information processing module of FIGURE 16, and includes evaluating region scores of zones to determine zone intersections in detected objects. The sequence includes evaluate region scores modules 872,874, set derived flags update counter/histories module 876, and an update top detection scores & safety zone latch module 878.

In an embodiment, an automatic door control and safety system is provided that controls door behavior in accordance with logic that interprets a nominally optically sensed object situation and environment proximate to the door. The system uses a camera sensor sub-system fitted with an appropriate lens in order to generate an image of the desired sensing area. Digital images produced by the camera sub-system are processed using image processing in a processing sub-system in order to develop data used to drive specific decision logic to effect desired door control. Thus, door control

is effected by computer interpretation of image content.

In an embodiment, from a processing point of view, the system incorporates several processing stages: 1) image formation; 2) image conditioning; 3) image processing; 4) image content processing; 5) derived data processing; 6) data interpretation processing; and 7) control logic processing.

The door control and safety system is supported by hardware elements to include the camera sub-system, and a general purpose processor sub-system that can be augmented by a digital signal processing device. The camera sub-system can include a lens system, a charge-coupled device imaging device, amplifiers, and an analog-to-digital conversion element. These element can be commonly found together in home computer applications, for example, which interface a digital camera to produce digital images on the computer screen for capture and storage for a variety of purposes.

The system uses a selection of image processing operators, implemented in an algorithm, and subsequent derived data processing and interpretation. The selected image processing operators and image content processing are derived through the optical phenomena exhibited by objects within the field of view of the camera. The image processing operates on the numbers contained in the array representative of scene determined though the lens and camera mounting geometry. This image processing creates internal arrays of numbers which are the results of the image processing, to be used by subsequent operations thus forming a sequence of image processing operations. In an embodiment of the system, the entire image field is processed. Furthermore, there are no prior assumptions about target objects used to develop any processing elements designed to match anticipated object characteristics for the purpose of selecting subsets of the entire image field.

At the beginning of the image processing sequence, the image processing accepts a new input image of the scene (which is a single time sample ("frame") of the on-going image digitization stream). Storage is provided in order to maintain a previous image frame for comparison to a newly captured image frame (a "background" image).

This stored image frame is captured in the same way as a new frame, and, in particular, is a single image frame, not an average of more than one frame.

In an embodiment, each new image frame is filtered to remove speckle noise using a median filter. The median filter removes isolated noise while not blurring the image as does averaging. Such isolation noise may be due to imaging sensor noise, downstream electronics noise or environmentally-produced scintillation. The image stored for comparison is filtered one with the median filter, as is the current image. The median filter in can be implemented as a 3 x 3 filter kernel that is passed over every pixel in the image array. The value at the center of the kernel is deposited in a new image array, and the value is that which is the median of the nine numbers in the filter kernel.

After image filtering, two new image arrays are generated (i.e., FIGURES 52 and 53). The first new image array (FIGURE 52) is determined as the pixel-by-pixel difference of the current image minus the background image ("positive contrast"). The second new image array (FIGURE 53) is determined as the pixel-by-pixel difference fo the background image minus the current image ("negative contrast"). The images are maintained as arrays of 8-bit numbers, so that when difference values are greater than 255 or less than 0, values are clipped accordingly.

After differencing, the images still contain 8-bit values. (Images with multiple bit levels are commonly referred to as grey-scale images). After image differencing, a thresholding operator is applied to each of the resulting positive and negative contrast grey-scale images. The threshold values applied to the two images may be different. The values can be fixed or adaptive wherein changes are made based on downstream image interpretation results. The pixel-by-pixel thresholding operation produces two new images. For each image, when the grey level in the input image exceeds the associated threshold value, a "1" is placed in the output image array, otherwise a "0" is placed. The result of the thresholding operation is thus two "binary" images.

Turning to FIGURES 54 and 55, selected binary image processing techniques

of mathematical morphology are applied to the binary images to facilitate downstream image interpretation. In an embodiment, operators are selected to remove isolated binary regions that could not be from significant objects, while improving the "connectedness" of larger regions that may be significant. Referred to as shape filtering, each of the two binary images are filtered similarly to the median filter mechanism (a 3x3 spatial kernel), except that the filter kernel operation is a maximum operator followed by a minimum operation, not the median operation. Such a filter is referred to as a binary closing or "close." A "close" is a "dilation" followed by an "erosion." The "dilation" is the maximum operation on the kernel, and the "erosion" is the minimum operation.

Turning to FIGURE 56, the two closed binary images (FIGURES 54 and 55) are logically OR-ed pixel-by-pixel to produce a resultant binary image representative of both positive and negative contrast differences with respect to the input images.

Turning to FIGURE 57, a connected components algorithm is applied to the resultant binary OR image (FIGURE 56). This algorithm identifies all the connected binary regions in the image. A connected region is one wherein every member pixel is a neighbor of at least one other member pixel. The connected components algorithm labels each region and builds a database containing derived features of each region. In an embodiment, the features can include region area, bounding rectangle, circularity, ellipse major and minor axis lengths, and perimeter. The region feature data is processed to select regions of interest. The regions are a direct result of the presence of the object in the field of view. No operator selection of sub-image regions of the total image field is involved in selecting the object-related regions - the regions are determined by the object.

With a database representative of image content, the features of each region are considered by interpretation logic to develop control logic decisions. In an embodiment, the interpretation logic is implemented as a set of "if-then-else" constructs, and can utilize arithmetic combination of the basic region features in order to determine image content interpretation. For instance, the resulting region area can be used to infer

the presence of an object of interest, and the region centroid and bounding rectangle determine the location of that object. (The bounding rectangle is the smallest rectangle that includes all pixels belonging to the region.)

In an embodiment, the operator can define rectangular regions of the image field of view to determine areas for specific control actions. The bounding rectangle coordinates of the computer-derived object regions of interest are compared to the coordinates of the operator-determined decision regions in order to determine subsequent control logic results. If an object is declared to be in the safety zone, for example, the control logic indicates that the door should remain open until the safety zone is clear. Similarly, if an object is determined to be in the activation zone (the binary region bounding rectangle representative of the image object intersects the activation zone decision rectangle), then the signal is sent to open the door. In an embodiment, the image regions selected by the operator for control logic purposes are not used in any way to initialize or otherwise influence the image processing of the entire image in order to determine image content.

While the specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention, and the scope of protection is only limited by the scope of the accompanying Claims.

CLAIMS

1. A detector comprising:

a sensor for collecting electromagnetic energy from a field of view for the sensor, the sensor generating a signal indicative of objects in the field of view;

an image analyzer electronically coupled to the sensor for receiving the sensor signal and forming an image of pixels therefrom;

an edge detector adapted to detect an edge of an object depicted within the pixel image, and determining the position of the edge within the pixel image;

a data storage device for storing edge location data of a first image; and

a comparator for comparing edge detection data from a second image to edge detection data from the first image in order to determine if the object associated with the edge has moved since the acquisition of the first image.

2. A shadow and light beam detection process comprising the steps of:

capturing a grey scale image;

generating a binary image to define a binary map of the grey scale image; and

comparing the binary map to a copy of the grey scale image to determine grey scale values corresponding to selected portions of the binary map.

3. A process for determining whether a discrete area appearing in image information for a field of view represents a shadow or a light beam anomaly comprising:

predetermining a characteristic of the anomaly;

predetermining a calculation that will quantify the characteristic;

applying the calculation to the image information and generating a quantity of the characteristic; and

classifying the area based upon the quantity calculated.

4. A process for determining an edge comprising:

predetermining a threshold value to apply to a grey scale image value in a first and second channel;

comparing the image value to the threshold value in each of the first and

second channel;

outputting a first binary value in each of the first and second channel;

defining a first dilation pixel having the first binary value;

defining a plurality of dilation pixels adjacent the first dilation pixel, each of the plurality of dilation pixels having a second binary value;

comparing the first binary value of the first dilation pixel and the second binary value of each of the plurality of dilation pixels;

outputting a dilated binary value in each of the first and second channel; and

oring the dilated binary value in the first channel and the dilated binary value in the second channel to generate an ored dilated binary value.

5. A process for determining an edge comprising:

storing a first grey scale image in a first buffer;

reading the first image;

transferring the first image to a second buffer;

repeating the steps of storing, reading and transferring for a second grey scale image;

subtracting the first image from the second image to generate a first positive image;

subtracting the second image from the first image to generate a second positive image;

comparing the first and second positive image to generate a positive difference image;

predetermining a threshold value to apply to the positive difference image in a first and second channel;

comparing the positive difference image to the threshold value in each of the first and second channel; and

outputting a first binary value in each of the first and second channel.

6. A motion detection process comprising the steps of:
capturing a first image;
determining edges of objects extant in the first image;
capturing a second image;
determining edges of objects extant in the second image;
subtracting the first image from the second image to generate a difference image; and
comparing at least one of the edge determinations to the difference image to determine movement of an object in the field of view represented by the at least one edge.

7. An image process for determining camera problems comprising the steps of:
capturing an image; and
creating a histogram to evaluate the image against pre-selected criteria.

8. An image process for determining camera problems comprising the steps of:
capturing a first image;
determining edges of the first image;
capturing a second image;
determining edges of the second image;
subtracting the second image from the first image to generate a difference image; and
thresholding the difference image.

9. An image process comprising the steps of:
capturing an image;
analyzing the image to define objects in the image;
labeling objects in the image; and
translating the objects to real world coordinates.

10. A process for determining an edge of an object in a field of view of a camera recording pixel data comprising:

capturing a reference frame of pixel data;

capturing an image frame of pixel data;

subtracting the reference frame from the image frame to generate a first gray scale contrast frame;

subtracting the image frame from the reference frame to generate a second gray scale contrast frame;

thresholding the first and second gray scale contrast frame to generate first and second contrast threshold frames;

dilating the first and second contrast threshold frames to generate first and second dilated frames;

oring the first and second dilated frames; and

adjusting the first and second dilated frames to generate a first and second binary images.

11. A process for smoothing pixel data defined as an edge of an object determined to exist in an image comprised of the pixel data, the process comprising the steps of:

defining a grey scale image from the pixel data in a first and second channel;

filtering the grey scale image utilizing a horizontal Sobel kernel to generate a horizontal filtered output in the first and second channel;

filtering the grey scale image utilizing a vertical Sobel kernel to generate a vertical filtered output in the first and second channel;

determining the absolute values of the horizontal and vertical filtered output in the first and second channel;

summing the absolute values to generate a Sobel value in the first and second channel; and

subtracting the Sobel value in the first channel from the Sobel value in the second channel to generate an output value.

12. A system for analyzing an image comprising:

a sensor configured and adapted to sense one of either active or passive

energy or both from a field of view;

an imager configured to form an image from the energy sensed by the sensor;

a processor responsive to the imager, the processor being configured and adapted to label image content information from the image; and

a decision maker responsive to the processor, the decision maker being configured and adapted to make determinations about the presence of a/an (stationary) object in the field of view from the image content information.

13. The system of claim 12 wherein the decision maker having a decision metric, the decision metric being based upon the relationship of selected image information content to a first predetermined area or zone within the image.

14. The system of claim 13 wherein the decision maker having a decision metric, the decision metric being based upon the relationship of selected image information content to a second predetermined area or zone within the image.

15. The system of claim 13 or 14 wherein the selected image information content is determined by the decision maker to be indicative of the object.

16. The system of claim 15 wherein the relationship to the area or zone is limited to whether at least a portion of the object is within the first or second predetermined zones.

17. The system of claim 13 or 14 wherein the selected image information content is determined by the decision maker to be indicative of an edge of the object.

18. The system of claim 13 or 14 wherein the selected image information content is determined by the decision maker to be indicative of a shadow of the object.

19. The system of claim 13 or 14 wherein the selected image information content is determined by the decision maker to be indicative of a lightbeam.

20. The system of claim 13 or 14 wherein the selected image information content is determined by the decision maker to be indicative of motion of the object.

21. The system of claim 12 wherein the processor is configured and adapted to determine features of the object selected from the group consisting of area, perimeter,

centroid, bounding rectangle, magnitude, variance and shape.

22. The system of claim 21 wherein the shape is selected from the group consisting of elongation, spread, ellipse shape factor and orientation.

23. A method of image analysis by a computing device comprising the steps of:

providing to the device, a pixel image of at least a portion of a field of view of a sensor;

the device determining pixels in the image which likely correspond to at least one edge of at least one object within the field of view; and,

the device labeling at least one group of the pixels identified to define an individual entity representative of the at least one edge of the at least one object in the field of view.

24. The method of claim 23 including the step of the device mathematically operating on the at least one object or the at least one group of pixels to generate at least one feature of the at least one object or the at least one group of pixels.

25. The method of claim 24 including the step of the device mathematically operating on the at least one object or the at least one group of pixels to generate a mathematical or geometric feature of the at least one object or the at least one group of pixels.

26. The method of claim 24 wherein the generating at least one feature step includes determining one or more features of the at least one object selected from the group consisting of area, perimeter, moments of inertia, grey level mean, grey level variance, grey level histogram and location.

27. A method of image analysis by a computing device comprising the steps of:

providing to the device, a pixel image of at least a portion of a field of view of a sensor;

the device quantifying multiple properties of all pixels in an area of interest;

the device labeling a first group of the pixels so as to satisfy a predetermined first criterion representative of an object in the field of view; and,

the device independently and simultaneously labeling a second group of the pixels so as to satisfy a predetermined second criterion representative of the object in the field of view.

28. The method of claim 27 including the step of the device mathematically operating on the object or the first and second group of pixels to generate at least one feature of the object or the first and second groups of pixels, respectively.

29. The method of claim 28 including the step of the device mathematically operating on the object or the first and second group of pixels to generate a mathematical or geometric feature of the object or the first and second groups of pixels, respectively.

30. The method of claim 28 wherein the generating at least one feature step includes determining one or more features of the object or the first and second groups of pixels selected from the group consisting of area, perimeter, moments of inertia, grey level mean, grey level variance, grey level histogram and location.

31. The method of claim 27 wherein the device performs the steps of:

mathematically operating on the object or the first and second groups of pixels to generate at least two features of the object or the first and second groups of pixels, wherein at least one feature is based on edge data and at least one feature is based on region analysis;

comparing the features of the object to a predefined set of rules stored in or accessible to the device; and,

the device generating a decision with respect to controlling a second device, based upon the comparison.

32. A method of image analysis comprising the steps of:

generating a time sequence of images in a field of view;

allocating one of the successive images, other than an immediately preceding image, in the field of view as a reference image; and,

comparing selected successive images to the reference image of the same field of view.

33. The method of claim 32 including the step of refreshing the reference image from time to time based on a criteria.

34. The method of claim 33 including the step of refreshing the reference image based upon evaluation of image content derived from the image comparisons.

35. The method of claim 33 including the step of refreshing the reference frame based upon a predetermined passage of time.

36. The method of claim 32 including the step of updating a portion of the reference image using a current image.

37. The method of claim 36 including the step of performing an update using predetermined criteria and evaluation of image content.

38. A method of image analysis comprising the steps of:

generating a time sequence of images in a field of view;

allocating one of the successive images in the field of view as a reference image; and,

comparing selected successive images to the reference image of the same field of view using a positive difference operator.

39. A method of image analysis comprising the steps of:

capturing an image;

deriving one or more images from the captured image using predetermined image operators;

labeling individual groups of pixels independently in one or more of the derived images corresponding to objects in the field of view; and

calculating features by evaluating the same groups of pixels for each of the one or more derived images independently.

40. The method of claim 39 including the step of considering the features simultaneously.

41. The method of claim 39 including the step of basing one of the features on edge data and another of the features on region data.

42. A camera system for controlling a device other than a camera comprising:

a camera having a lens, the lens having at least a first and second radial distortion coefficient, the first coefficient having a value of at least about 1.0 and the second coefficient having an absolute value of at least about 1.0;

a signal generator for generating a camera signal indicative of a field of view through the lens;

an analyzer which receives the camera signal and analyzes the camera signal for detection of an object or motion, the analyzer generating a detection signal indicating the object or motion; and,

a device controller receiving the detection signal and controlling the device in response thereto.

43. The system of claim 42 wherein the analyzer having means for analyzing image content while compensating for the radial distortion.

44. The system of claim 43 wherein the analyzer determines the radial distortion.

45. The system of claim 42 wherein the analyzer having means for determining the size of objects in the field of view.

46. The system of claim 42 including code for representing radial distortion as a standard radial distortion polynomial system wherein the polynomial system having sixth-powered terms, the coefficients of which are non-zero.

47. A camera system for controlling a device other than a camera comprising:

a camera having a lens, the lens having a field of view of at least about 53 degrees;

a signal generator for generating a camera signal indicative of the field of view through the lens;

an analyzer which receives the camera signal and analyzes the camera signal for detection of an object or motion, the analyzer generating a detection signal indicating the object or motion; and,

a device controller receiving the detection signal and controlling the device

in response thereto.

48. The system of claim 47 wherein the lens having a field of view of at least 90 degrees.

49. The system of claim 47 wherein the analyzer having means for analyzing image content while compensating for the radial distortion.

50. The system of claim 49 wherein the analyzer determines the radial distortion.

51. The system of claim 47 wherein the analyzer having means for determining the size of objects in the field of view.

52. The system of claim 47 including code for representing radial distortion as a standard radial distortion polynomial system wherein the polynomial system having sixth-powered terms, the coefficients of which are non-zero.

53. A camera system for controlling a device other than a camera comprising:

a camera having a lens, the lens having an image diagonal and a focal length, wherein the image diagonal is greater than the focal length;

a signal generator for generating a camera signal indicative of the field of view through the lens;

an analyzer which receives the camera signal and analyzes the camera signal for detection of an object or motion, the analyzer generating a detection signal indicating the object or motion; and,

a device controller receiving the detection signal and controlling the device in response thereto.

54. The system of claim 53 wherein the image diagonal is at least twice the focal length.

55. The system of claim 53 wherein the analyzer having means for analyzing image content while compensating for the radial distortion.

56. The system of claim 55 wherein the analyzer determines the radial distortion.

57. The system of claim 53 wherein the analyzer having means for determining the size of objects in the field of view.

58. The system of claim 53 including code for representing radial distortion as a standard radial distortion polynomial system wherein the polynomial system having sixth-powered terms, the coefficients of which are non-zero.

59. A camera comprising:

a) a lens;

b) a detector located so as to have light focused upon the detector from the lens, the detector generating an image signal;

c) a controller receiving the image signal; and

d) a gain control adjusting gain of the image signal from the detector based upon a histogram of grey-scale values of the image.

60. The camera of claim 59 wherein the detector is selected from the group consisting of a CCD-based detector and a CMOS-based detector.

61. A method of image processing comprising the steps of:

capturing a pixel image of a field of view from a single point of view;

electronically analyzing the image to determine pixel groups in the image corresponding to objects in the field of view; and

determining the spatial location of objects in the field of view corresponding to the pixel groups.

62. A method of image processing comprising the steps of:

providing an array of sensors, the array having a first field of view of a volumetric space;

defining a two-dimensional pixel image from signals sent from the array; (the pixel image providing a two-dimensional representation of the volumetric space)

predetermining a desired coordinate system in the volumetric space; and,

utilizing information regarding a pose of the array and the coordinate system to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

63. The method of claim 62 including the steps of:

providing a lens with a radial distortion to focus energy from a second field of view to the array; and,

adjusting the relation of pixel values to spatial location.

64. The method of claim 62 including the step of electronically determining the effective resolution of the array of sensors within the field of view relative to the coordinate system unit of measure.

65. The method of claim 64 including the step of controlling a detection characteristic over the entire field of view by utilizing the determined resolution values.

66. The method of claim 64 including the step of adjusting detection threshold limits by utilizing the determined resolution values.

67. The methods of claims 64-66 including the step of predetermining a pixel area corresponding to a representative size of objects of interest for detection.

68. The method of claim 62 including the step of providing an array of sensors arranged in a substantially planar relationship.

69. The method of claim 62 including the step of utilizing information regarding location and orientation of the array and the coordinate system to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

70. The method of claim 62 including the step of utilizing information regarding intrinsic parameters of the imaging system and the coordinate system to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

71. The method of claim 62 including the step of predetermining a homogeneous coordinate system in the volumetric space.

72. The method of claim 71 including the step of utilizing information regarding a pose of the array and the homogeneous coordinate system to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

73. The method of claim 71 including the step of utilizing a projective perspective transformation to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

74. The method of claim 73 including the step of adding a radial distortion correction to the projective perspective transformation to electronically determine the relation between pixel coordinates in the image to spatial coordinates in the three-dimensional space.

75. The method of claim 62 including the step of providing a CCD, the CCD having a first field of view of a volumetric space.

76. A method of image analysis comprising the steps of:

providing a pixel image of at least a portion of a field of view of a sensor;

determining pixels in the image which likely correspond to objects in the field of view;

discriminating between pixels so determined to define spatially discrete groups of pixels; and,

labeling each group of pixels.

77. A timer for monitoring a processor comprising:

a first circuit for resetting the processor when improper function is detected; and

a second circuit for maintaining a safe output condition when the processor is not controlling the output condition.

78. The timer of claim 77 including a temperature monitor.

79. The timer of claim 78 wherein the temperature monitor generates an output signal when the processor temperature exceeds predetermined operating limits.

80. The timer of claim 79 wherein the temperature monitor is connected to the first circuit for resetting the processor when the processor temperature exceeds the predetermined operating limits.

81. A monitoring device comprising:

a sensor for sensing energy from an environment and providing an output indicative of same;

an image formed from the output of the sensor;

a first analyzer for analyzing a first portion of the image; and

a second analyzer for analyzing a second portion of the image distinct from the first portion of the image and each generating a signal indicative of the respective portion of the image analyzed by the respective analyzer.

82. A monitoring device comprising:

a sensor for sensing energy from an environment and providing an output indicative of same;

an image formed from the output of the sensor;

n analyzers for analyzing n portions of the image, each portion being distinct; and

each analyzer generating a signal indicative of the respective portion of the image analyzed by the respective analyzer.

83. A camera having a lens and optionally a transparent lens cover and having a field of view through the lens and optionally through the lens cover comprising:

a storage device for storing logic and data and codifying criteria representative of conditions having an effect on the field of view;

an imager for obtaining and storing an image representative of the field of view;

a processor for processing data derived from the image for use in comparison to the criteria; and

a generator for generating control signals representative of the image.

84. The camera of claim 83 including frame analysis algorithms for evaluating image quality of the camera.

85. The camera of claim 83 including frame analysis algorithms for evaluating changes in position or orientation of the lens relative to camera environment.

86. The camera of claim 83 including frame analysis algorithms for evaluating image failure of the camera.

87. The camera of claim 83 wherein the conditions that impact the view through the lens and optionally a lens cover are selected from the group consisting of substances contacting the lens or lens cover, level of lighting in the view, unusually bright or dark spots in the view, overall flux of electromagnetic energy passing through the lens, and obstruction of the lens by other objects.

88. The camera of claim 83 wherein the processor has a generator for generating histograms from the image and the storage device has data relative to histogram criteria.

89. The camera of claim 88 wherein the data relative to histogram criteria is derived by a comparison between a predetermined histogram and a histogram determined from the image representative of the field of view.

90. The camera of claim 87 wherein the processor has a generator for generating histograms from the image and the storage device has data relative to histogram criteria.

91. The camera of claim 90 wherein the data relative to histogram criteria is derived by a comparison between a predetermined histogram and a histogram determined from the image representative of the field of view.

92. The camera of claims 87-91 wherein the substances contacting the lens or lens cover are selected from the group consisting of dirt, dust, oil, water, organic film, inorganic film, soot and metal fines.

93. The camera of claim 83 wherein the conditions are selected from the group consisting of normal and abnormal.

94. A system for defogging a window comprising:

an electrically conductive terminal; and

a PTC material adjoining the conductive terminal and operably coupled to the window.

95. The system of claim 94 further comprising another electrically conductive terminal adjoining the PTC material.

96. The system of claim 95 further comprising a voltage potential coupled to the electrically conductive terminals.

97. The system of claim 94 wherein the electrically conductive terminal has an aperture extending therethrough.

98. The system of claim 94 wherein the PTC material has an aperture extending therethrough.

99. The system of claim 94 wherein the electrically conductive terminal and the PTC material have apertures extending therethrough and in coaxial alignment with each other.

100. An apparatus comprising:

a housing having an opening;

a window mounted over the opening;

a PTC material operably coupled to the window.

101. The apparatus of claim 100 further comprising an electrically conductive terminal connected to the PTC material.

102. The apparatus of claim 101 further comprising another electrically conductive terminal adjoining the PTC material.

103. The apparatus of claim 101 further comprising a voltage potential coupled to the electrically conductive terminal.

104. The apparatus of claim 101 wherein the electrically conductive terminal has an aperture extending therethrough.

105. The apparatus of claim 100 wherein the PTC material has an aperture extending therethrough.

106. The apparatus of claim 101 wherein the electrically conductive terminal and the PTC material have apertures extending therethrough and in coaxial alignment with each other and the opening in the housing.

107. The apparatus of claim 100 further comprising a camera mounted within the housing.

108. The apparatus of claim 107 wherein the camera has a field-of-view extending through the window.

109. The apparatus of claim 108 wherein the field-of-view includes at least part of a pathway to a door.

110. The apparatus of claim 109 further comprising a door opener operably coupled to the door and responsive to objects detected within the field-of-view.

111. An input device for communicating with a controller for an automatic door comprising:

a first sequencing key which is configured to prompt a user to enter a first set of data into the device when actuated a first time and prompt the user to enter a second set of data when actuated a second time;

at least one input key; and

at least one input.

112. The device of claim 111 including a display for displaying user input.

113. The device of claim 111 including a display for displaying pre-stored user options for selection in response to prompts from the first sequencing key.

114. The device of claim 113 wherein the display displaying only a portion of the pre-stored data to be displayed for each actuation of the at least one input key.

115. The device of claims 111-114 including an input selector which accepts and stores user input when actuated.

116. The device of claims 112-115 including a second sequencing key which is configured to prompt a user to enter a third set of data into the device using a first display key when actuated a first time and prompt the user to enter a fourth set of data into the device using the first display key when actuated a second time.

117. The device of claims 112-115 including a second sequencing key which is configured to prompt a user to enter a third set of data into the device using the first display key when actuated a first time and prompt the user to enter a fourth set of data into the device using a second display key when actuated a second time.

118. The device of claims 112-117 including a third sequencing key which is configured to prompt a user to enter a fifth set of data into the device using a first display key when actuated a first time and prompt the user to enter a sixth set of data into the device using the first display key when actuated a second time.

119. The device of claims 112-117 including a third sequencing key which is configured to prompt a user to enter a fifth set of data into the device using the first display key when actuated a first time and prompt the user to enter a sixth set of data into the device using a second display key when actuated a second time.

120. The device of claim 116 wherein the first and second sequencing keys are configured with a hierarchy, the hierarchy allowing the first sequencing key to override operation of the second sequencing key.

121. The device of claim 118 wherein the first and third sequencing keys are configured with a hierarchy, the hierarchy allowing the first sequencing key to override operation of the third sequencing key.

122. The device of claim 118 wherein the first, second and third sequencing keys are configured with a hierarchy, the hierarchy allowing the first sequencing key to override operation of the second and third sequencing keys.

123. The device of claim 111 wherein the at least one input is a numerical input.

124. The device of claim 111 wherein the at least one input is an alpha input.

125. A sensor system for controlling an automatic door which has a door panel selectively blocking an opening comprising:

a sensor having a field of view of areas of interest about the opening and a signal output relative to objects sensed in the field of view of the sensor;

a signal processor responsive to sensor output signals;

a door drive responsive to the signal processor; and

an input device having a signal output, the signal processor responsive to output signals from the input device,

wherein the input device having a pose input for permitting a user to input

data indicative of the pose of the sensor as mounted to obtain the field of view.

126. The sensor system of claim 125 wherein the pose input includes installed height of the sensor.

127. The sensor system of claim 125 wherein the pose input includes a nominal height of the sensor.

128. The sensor system of claim 125 wherein the pose input includes a model number of the door associated with the field of view.

129. The sensor system of claim 125 wherein the pose input includes a width of the opening.

130. The sensor system of claim 125 wherein the pose input includes a length of the opening.

131. The sensor system of claim 125 wherein the pose input includes a first position of an activation zone.

132. The sensor system of claim 125 wherein the pose input includes a second position of an activation zone.

133. An input device for communicating with a door drive responsive to a sensor which has a field of view of areas of interest about the door, the device comprising:

a first tier of selectable input selectors; and

a second tier of selectable input selectors;

wherein the first and second tiers being configured such that user input into the first tier of selectable input selectors controls the availability of selections for input on the second tier of selectable input selectors.

134. A sensor system for controlling an automatic door which has a door panel selectively blocking an opening, the sensor system comprising:

a sensor configured to sense objects in a field of view; and

an input device having an output for communication with a controller for the automatic door, the input device having a user input relative to the sensor height.

135. The system of claim 134 wherein the input device having a user input relative

to the door width.

136. The system of claim 134 wherein the input device having a data set stored relative to door model.

137. An image analyzer for data processing comprising:

a FPGA for pixel processing;

a CPU operably connected to the FPGA in parallel; and

a video buffer operably connected to the CPU.

138. A process for performing high-rate data processing comprising the steps of:

providing a CPU for processing a current frame;

providing a FPGA for simultaneously processing a next frame to generate a FPGA output;

storing the FPGA output in a storage bank;

retrieving the FPGA output from the storage bank; and

sending the FPGA output to the CPU for processing.

139. A process for initializing a video system comprising the steps of:

initializing a FPGA;

selecting a first ping-pong data set;

instructing the FPGA to capture a video frame;

initializing at least one reference image;

instructing the FPGA to process the at least one reference image to generate FPGA outputs; and

transferring the FPGA outputs from the FPGA to the first ping-pong data set.

140. A system for controlling an effector comprising:

a sensor configured and adapted to sense one of either active or passive energy or both from a field of view;

an imager configured to form an image from the energy sensed by the sensor;

an image analyzer responsive to the imager, the image analyzer being configured and adapted to define image content information from the image;

a decision maker responsive to the image analyzer, the decision maker being adapted and configured to make determinations about the presence of a/an (stationary) object in the field of view from the image content information; and,

a first controller for controlling the effector, the first controller being responsive to the decision maker.

141. The system of claim 140 wherein the decision maker having a first decision metric, the first decision metric being based upon the relationship of selected image information content to a first predetermined area or zone within the image.

142. The system of claim 141 wherein the decision maker having a first decision metric, the first decision metric being based upon the relationship of selected image information content to a second predetermined area or zone within the image.

143. The system of claim 141 or 142 wherein the selected image information content is determined by the decision maker to be indicative of the object.

144. The system of claim 143 wherein the relationship to the area or zone is limited to whether at least a portion of the object is within the first or second predetermined zones.

145. A system for controlling an automatic door which selectively blocks an opening, the system comprising:

a sensor configured and adapted to sense one of either active or passive energy or both from a field of view;

an imager configured to form an image from the energy sensed by the sensor;

an image analyzer responsive to the imager, the image analyzer being configured and adapted to define image content information from the image;

a decision maker responsive to the image analyzer, the decision maker being adapted and configured to make determinations about the objects in the field of view based upon the image content information; and,

a door controller for controlling at least the opening and closing of the door, the door controller being responsive to the decision maker.

146. The system of claim 145 wherein the decision maker having a first decision metric, the first decision metric being based upon the relationship of selected image information content to a first predetermined area or zone within the image.

147. The system of claim 146 wherein the decision maker having a first decision metric, the first decision metric being based upon the relationship of selected image information content to a second predetermined area or zone within the image.

148. The system of claim 146 or 147 wherein the selected image information content is indicative of the presence of a stationary object.

149. The system of claim 148 wherein the relationship to the area or zone includes whether at least a portion of the object is within the first or second predetermined zones.

150. The system of claim 146 or 147 wherein the relationship to the area or zone includes whether at least a portion of an object is within the first or second predetermined zones.

151. The system of claim 145 including a geometry mapper which translates the dimensions and geometries of the field of view to coordinates of pixels comprising the images.

152. An object position locator consisting of a single camera for generating pixel images for analysis, comprising:

an image analyzer having an object detection algorithm which determines the existence of objects in a field of view of the camera;

a labeler for providing a discrete identity to an object in the pixel image; and

a position locator for determining coordinates of the object within the pixel image.

153. A monitoring device comprising:

a sensor for sensing energy from an environment and providing an output indicative of same;

an image formed from the output of the sensor;

n analyzers for analyzing n portions of the image, each portion being distinct;

and

each analyzer generating a signal indicative of the respective portion of the image analyzed by the respective analyzer.

154. A surveillance system comprising:

multiple sensors, each sensor being deployed at an individual location of interest, each sensor having a field of view and generating a sensor signal indicative of objects within its field of view;

one or more signal analyzers for receiving sensor signals and determining from the signals the presence of objects of interest or motion in the respective fields of view of the multiple sensors, and for generating a display signal representative of the multiple fields of view and for generating detection signals indicative of object presence or motion in respective ones of the multiple fields of view;

at least one viewer for receiving display signals and generating and displaying human interpretable data representative of selected fields of view; and

a controller receiving at least the detection signals from the signal analyzers, the controller determining from the detection signals which field of view will be displayed on the at least one viewer.

155. A system for defogging a window comprising:

an electrically conductive terminal; and

a PTC material adjoining the conductive terminal and operably coupled to the window.

156. The system of claim 155 further comprising another electrically conductive terminal adjoining the PTC material.

157. The system of claim 156 further comprising a voltage potential coupled to the electrically conductive terminals.

158. The system of claim 155 wherein the electrically conductive terminal has an aperture extending therethrough.

159. The system of claim 155 wherein the PTC material has an aperture extending

therethrough.

160. The system of claim 155 wherein the electrically conductive terminal and the PTC material have apertures extending therethrough and in coaxial alignment with each other.

161. An apparatus comprising:

a housing having an opening;

a window mounted over the opening;

a PTC material operably coupled to the window.

162. The apparatus of claim 161 further comprising an electrically conductive terminal connected to the PTC material.

163. The apparatus of claim 162 further comprising another electrically conductive terminal adjoining the PTC material.

164. The apparatus of claim 162 further comprising a voltage potential coupled to the electrically conductive terminal.

165. The apparatus of claim 162 wherein the electrically conductive terminal has an aperture extending therethrough.

166. The apparatus of claim 161 wherein the PTC material has an aperture extending therethrough.

167. The apparatus of claim 162 wherein the electrically conductive terminal and the PTC material have apertures extending therethrough and in coaxial alignment with each other and the opening in the housing.

168. The apparatus of claim 161 further comprising a camera mounted within the housing.

169. The apparatus of claim 168 wherein the camera has a field-of-view extending through the window.

170. The apparatus of claim 169 wherein the field-of-view includes at least part of a pathway to a door.

171. The apparatus of claim 170 further comprising a door opener operably

coupled to the door and responsive to objects detected within the field-of-view.

172. A system for controlling a door comprising:

a camera for collecting image data;

a control unit receiving image data from the camera; and

a drive motor for controlling the opening and closing of the door, the drive motor receiving control signals from the control unit.

173. The system of claim 172 wherein the control unit has means for defining at least a portion of an image as a control zone.

174. The system of claim 173 including a first control zone wherein selected image data within the first control zone will cause a control signal to open the door.

175. The system of claim 173-174 including a second control zone wherein selected image data within the second control zone will generate a first control condition preventing the door from closing.

176. The system of claim 173 wherein the means for defining includes choosing coordinates from all pixel coordinates by direct access within the control zone.

177. The system of claim 173 wherein the means for defining includes choosing from multiple predefined zones.

178. The system of claim 173 wherein the means for defining includes putting real objects in a field of view so as to delineate boundary coordinates and the real objects become part of the image data, the control zone being defined from the real objects image data.

179. The system of claim 172-174 wherein

the control unit analyzes the image data in the first control zone at a first time;

the control unit analyzes the image data in the first control zone at a second time; and

the control unit compares the image data at the first time and the image data at the second time to determine whether an object is present in the first control zone.

180. The system of claim 179 wherein the object is analyzed to determine if any portion of the object is within the first control zone.

181. The system of claim 180 wherein the selected image data within the first control zone causes the control signal to open the door if any portion of the object is within the first control zone.

182. The system of claim 181 wherein the control unit chooses a portion of the object to determine a bottom edge of the object.

183. The system of claim 182 wherein the control unit analyzes the bottom edge to determine if the bottom edge is within the first control zone.

184. The system of claim 183 wherein a fourth control zone is defined adjacent the first control zone, the fourth control zone possessing objects between the first control zone and the camera.

185. The system of claim 184 wherein the fourth control zone is positioned between the first control zone and the camera.

186. The system of claim 185 wherein the presence of the object in the fourth control zone will prevent the first control zone from sending the control signal to open the door.

187. The system of claim 186 wherein the presence of the object in the fourth control zone will cause the first control zone to send the control signal to open the door.

188. The system of claim 172-175 wherein

the control unit analyzes the image data in the second control zone at a first time;

the control unit analyzes the image data in the second control zone at a second time; and

the control unit compares the image data at the first time and the image data at the second time to determine whether an object is present in the first control zone.

189. The system of claim 172-175 further including a third control zone wherein selected image data within the third control zone will generate a second control condition

preventing the door from closing.

190. The system of claim 172-175 wherein the second control zone comprises a plurality of predetermined shapes.

191. The system of claim 189-190 wherein the third control zone comprises a plurality of predetermined shapes, the shapes of the third control zone being complementary to the shapes of the second control zone.

192. The system of claim 191 wherein

the control unit analyzes the image data in the third control zone at a first time;

the control unit analyzes the image data in the third control zone at a second time; and

the control unit compares the image data at the first time and the image data at the second time to determine whether an object is present in the third control zone.

193. The system of claim 172-174 wherein the first control zone includes means for comparing the image data to a plurality of user specified dimensions.

194. The system of claims 172-193 wherein the camera senses energy selected from the group consisting of: visible light waves, infrared lights waves, microwaves, radar and sound waves.

195. The system of claim 173-194 wherein a user can enter data to define at least one control zone parameter from the group consisting of area, location, shape, number of control zones and control criteria.

196. The system of claims 1-194 wherein the sensor is a camera.

197. A system for controlling a door comprising:

a sensor, the sensor having, for example, a beam for sensing coherent energy from objects near the door;

a control unit receiving electronic values from the sensor indicative of energy sensed by the camera;

a drive motor for controlling the opening and closing of the door, the drive

motor receiving control signals from the control unit; and

means for defining a portion of a beam pattern as a control zone.

198. The system of claim 197 wherein the control zone is a beam pattern

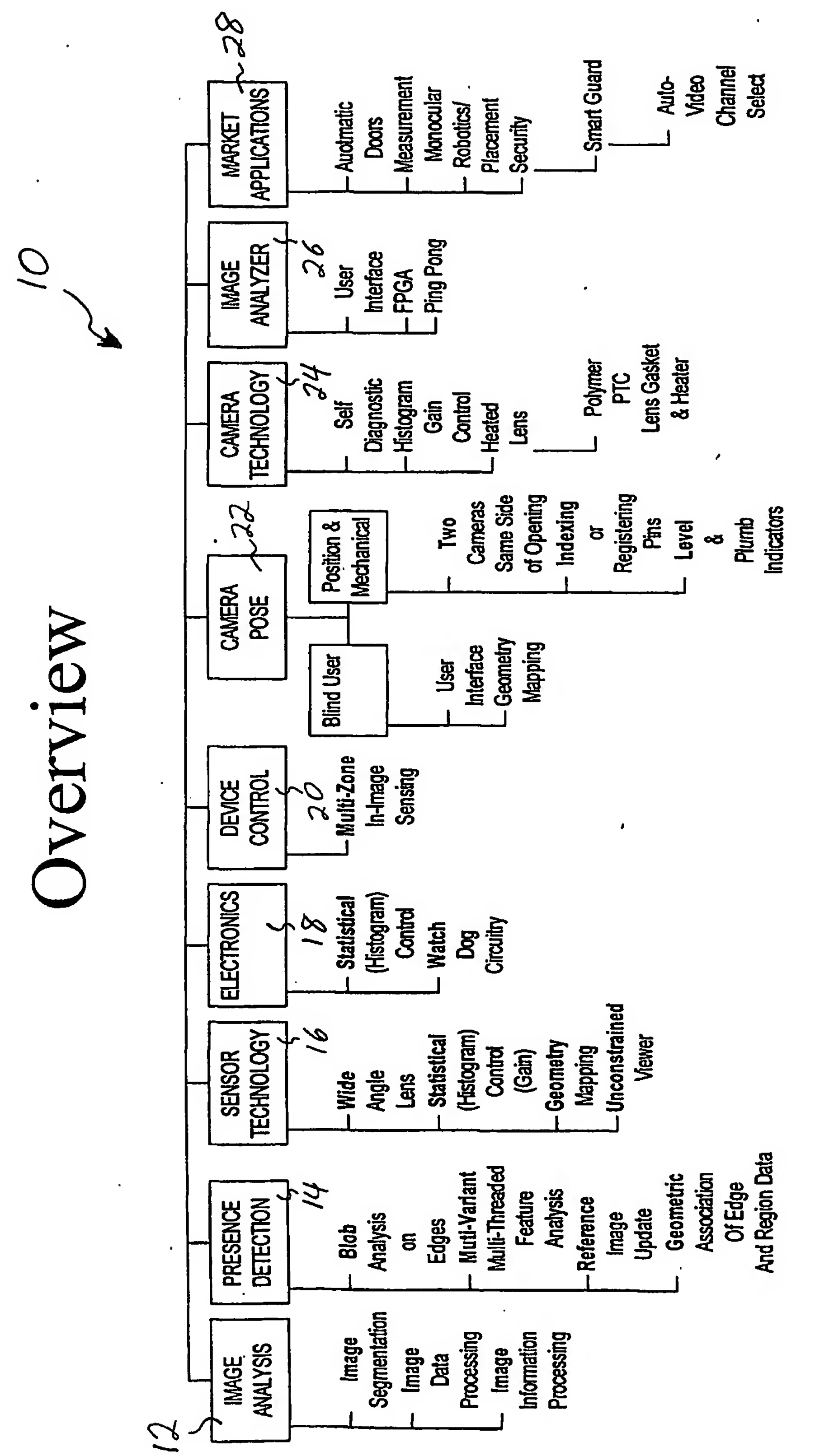

Overview
10
IMAGE ANALYSIS
12
Image Segmentation
Image Data Processing
Image Information Processing
PRESENCE DETECTION
14
Blob Analysis on Edges
Multi-Variant Multi-Threaded Feature Analysis
Reference Image Update
Geometric Association Of Edge And Region Data
SENSOR TECHNOLOGY
16
Wide Angle Lens
Statistical (Histogram) Control (Gain)
Geometry Mapping
Unconstrained Viewer
ELECTRONICS
18
Statistical (Histogram) Control
Watch Dog Circuitry
DEVICE CONTROL
20
Multi-Zone In-Image Sensing
CAMERA POSE
22
Blind User
User Interface Geometry Mapping
Position & Mechanical
Two Cameras Same Side of Opening
Indexing or Registering Pins
Level & Plumb Indicators
CAMERA TECHNOLOGY
24
Self Diagnostic
Histogram Gain Control
Heated Lens
Polymer PTC Lens Gasket & Heater
IMAGE ANALYZER
26
User Interface
FPGA
Ping Pong
MARKET APPLICATIONS
28
Automatic Doors
Measurement
Monocular Robotics/ Placement
Security
Smart Guard
Auto-Video Channel Select

Figure 1

Hardware Block Diagram

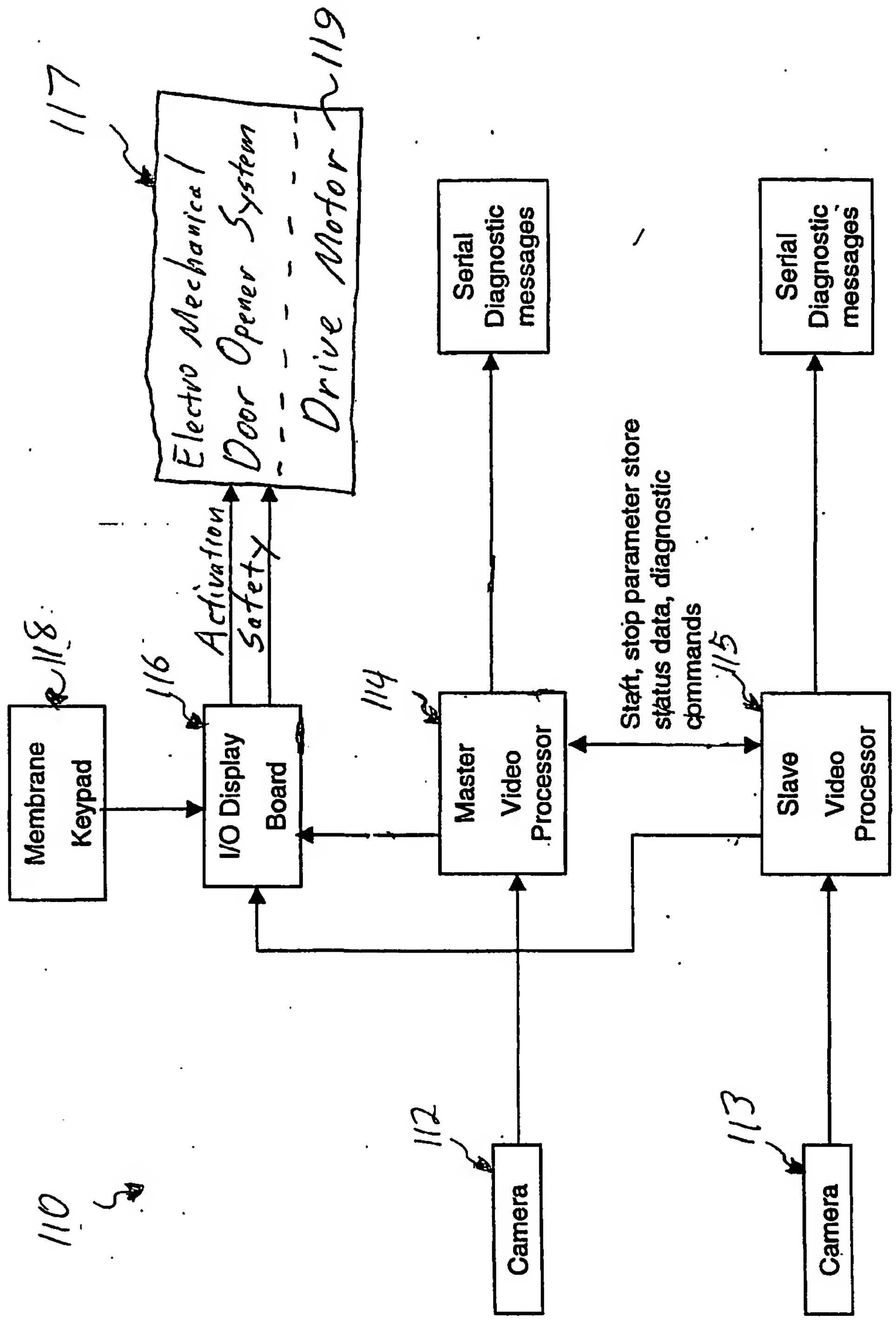


Fig. 2

Fig. 3

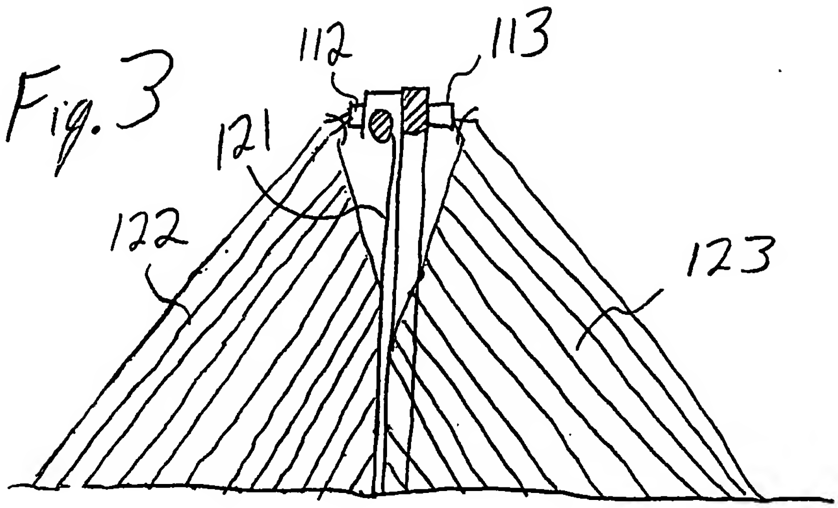
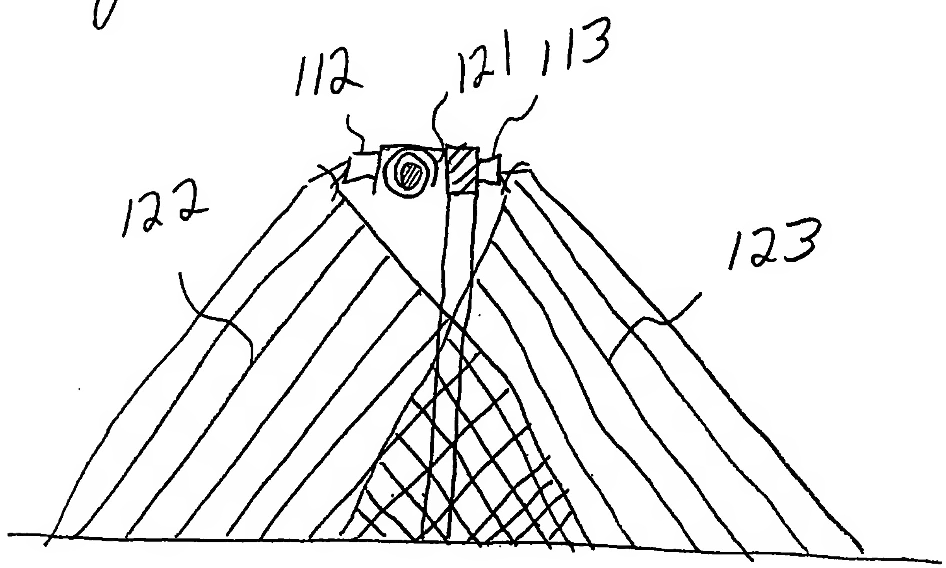


Fig. 4



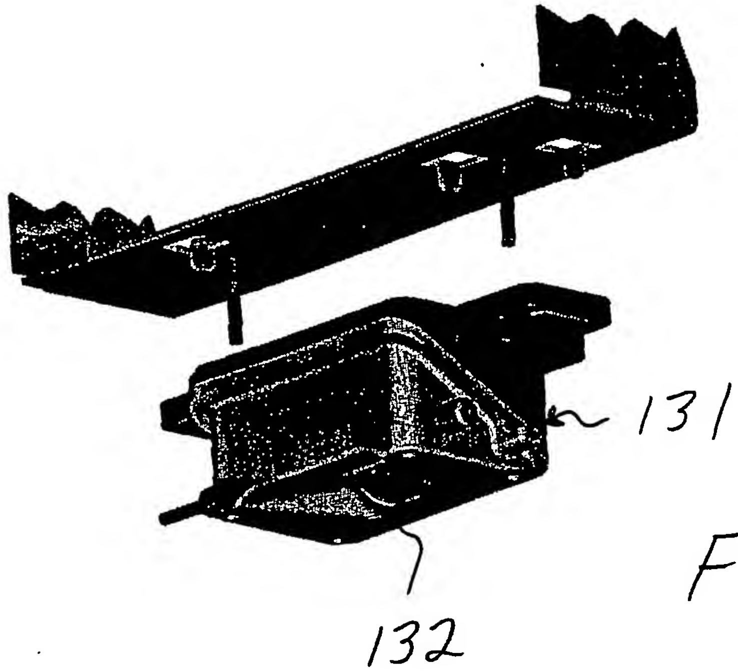


Figure 5

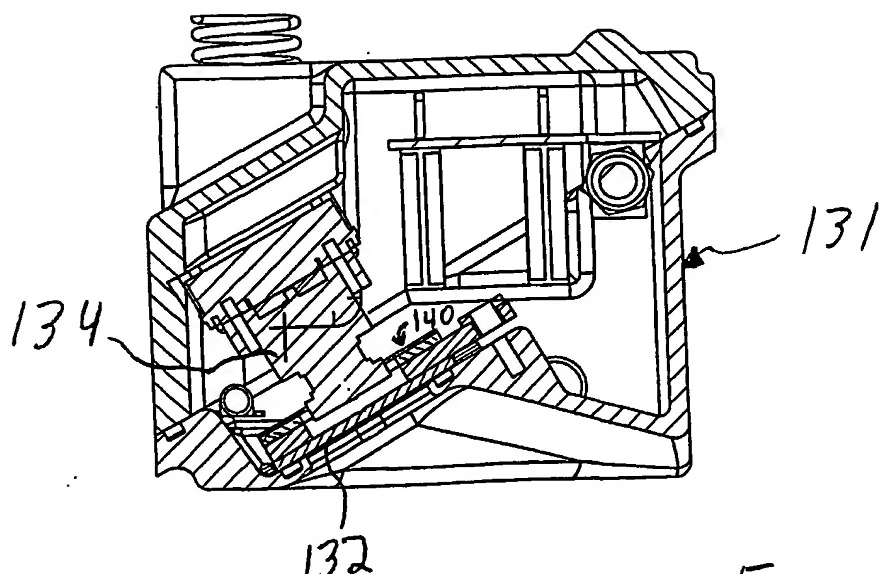


Figure 6

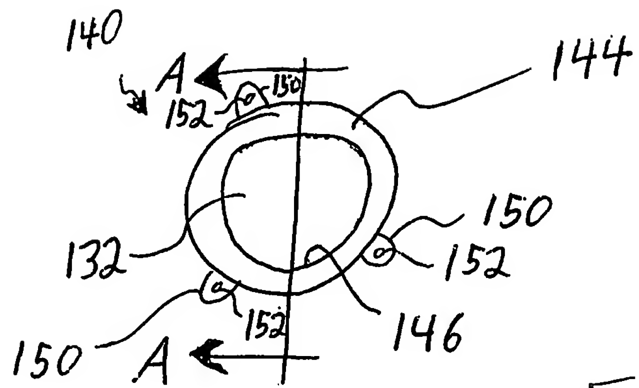


Figure 7

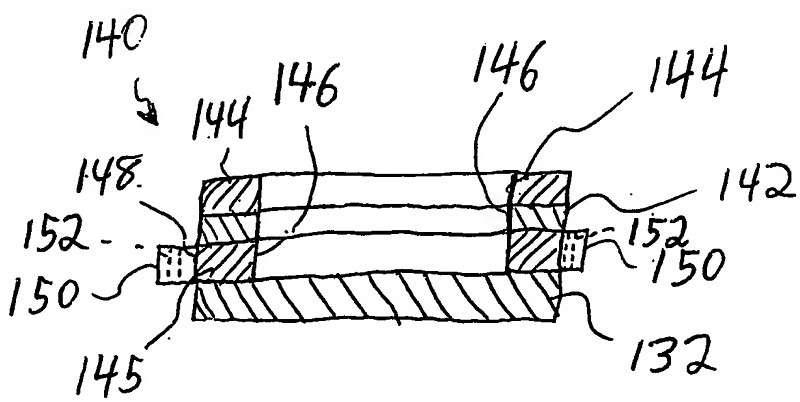


Figure 8

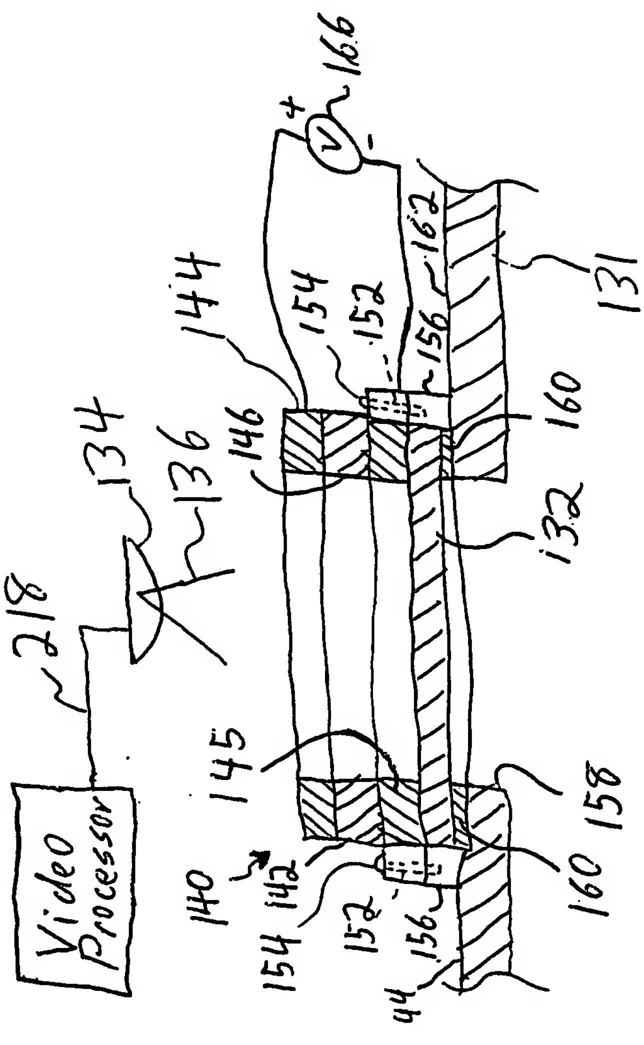

Video Processor
218
134
136
146
144
154
152
156
162
166
+
-
V
131
160
132
145
140
142
154
152
156
44
160
158

Figure 9

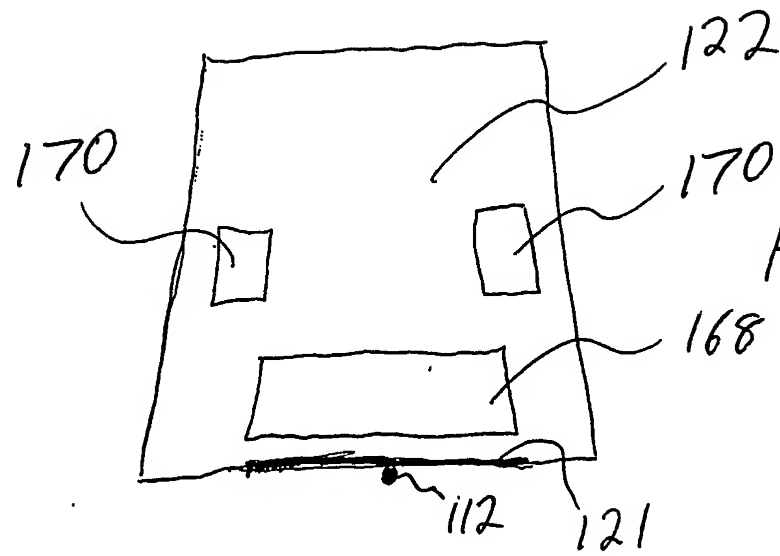


Figure 10

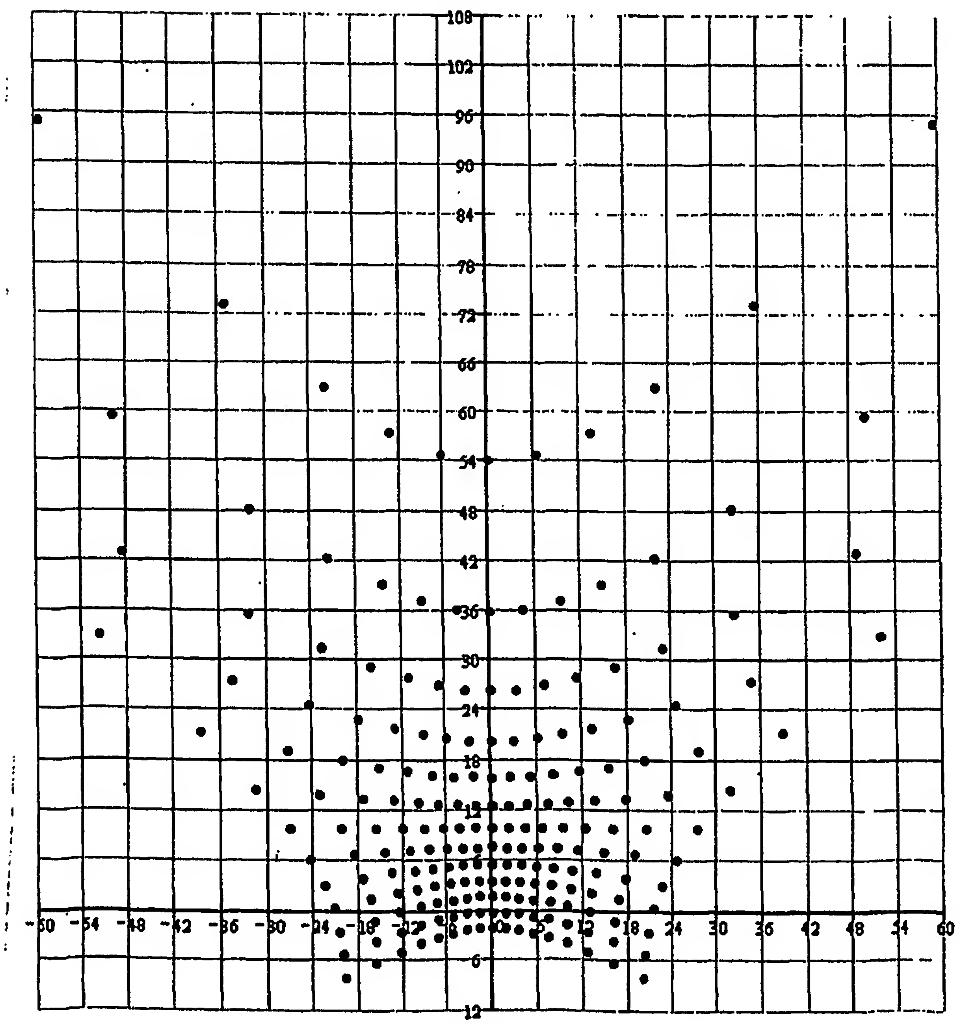


Figure 11

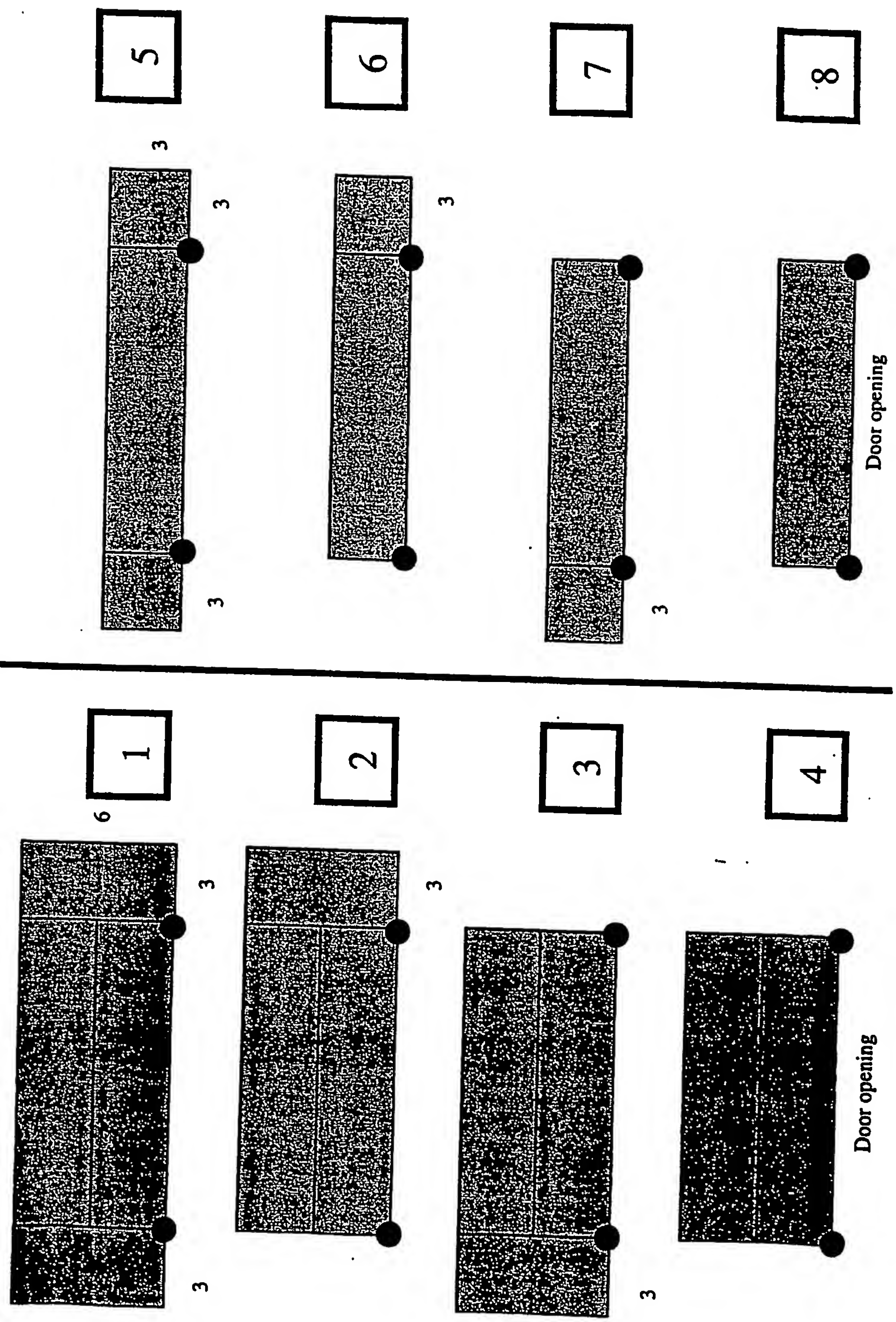


Figure 12

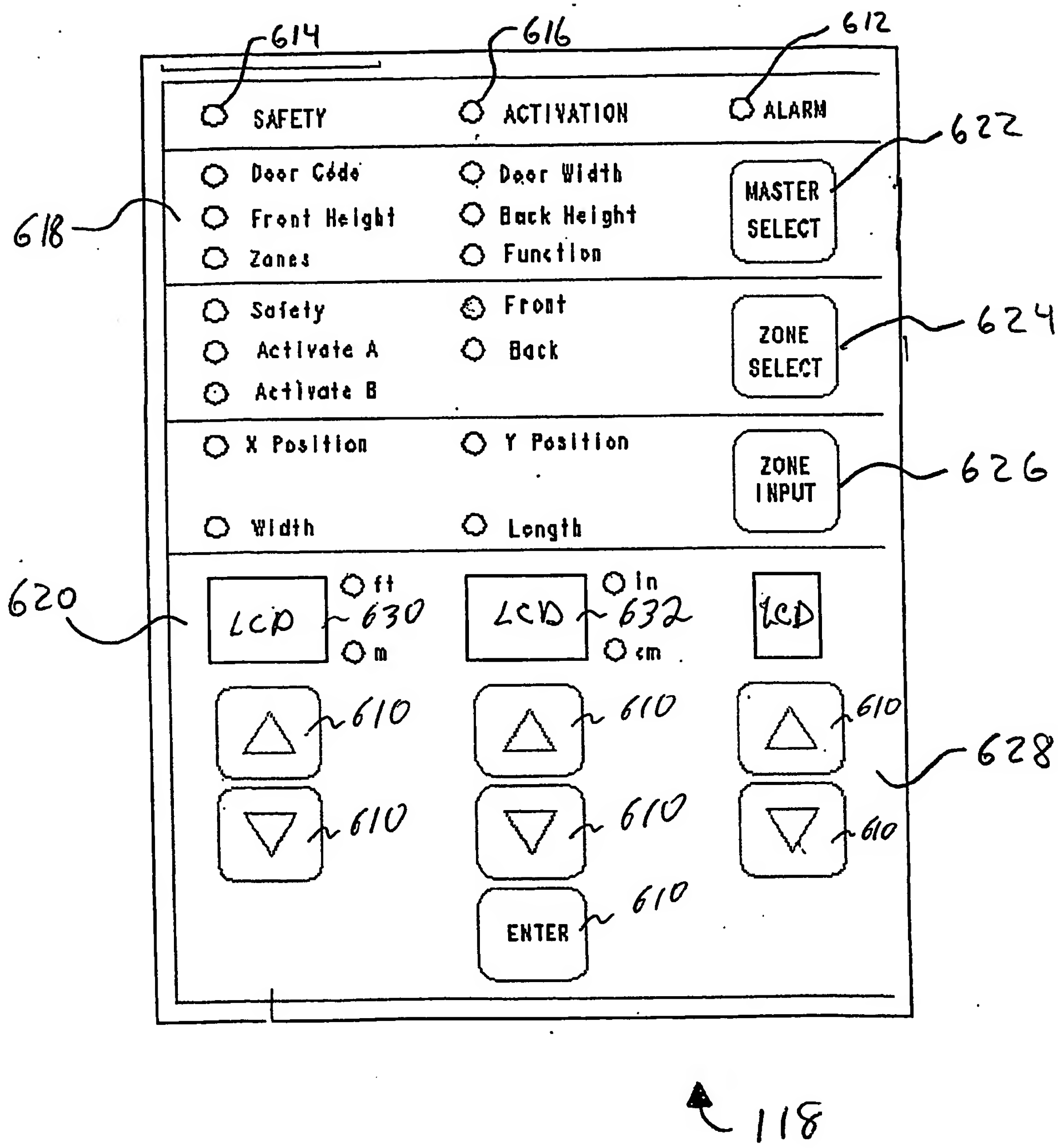

614
616
612
SAFETY
ACTIVATION
ALARM
622
Door Code
Door Width
MASTER SELECT
618
Front Height
Back Height
Zones
Function
Safety
Front
ZONE SELECT
624
Activate A
Back
Activate B
X Position
Y Position
ZONE INPUT
626
Width
Length
620
LCD
ft
630
m
LCD
in
632
cm
LCD
610
628
ENTER
118

Figure 13

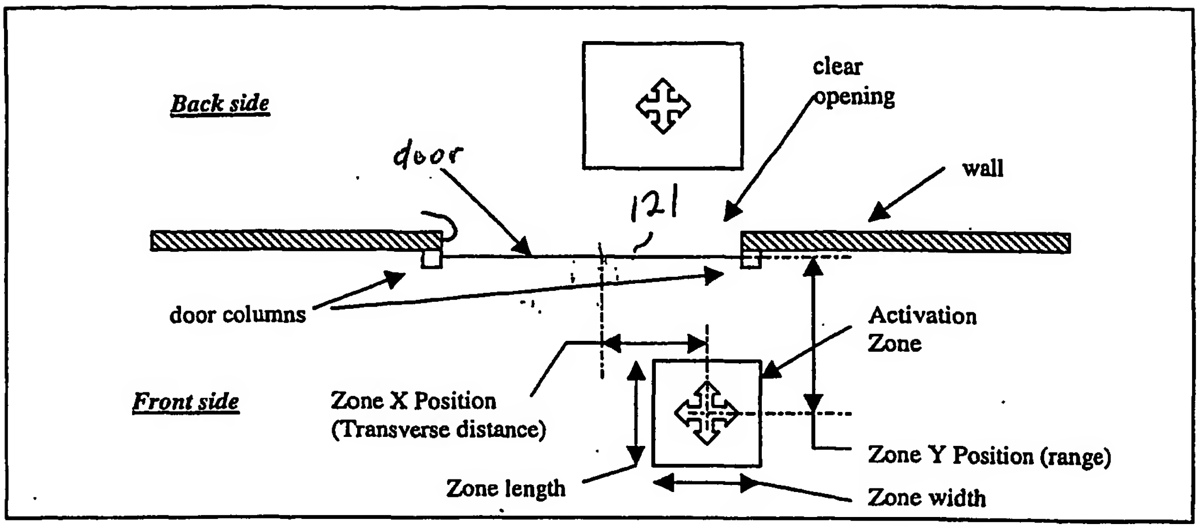
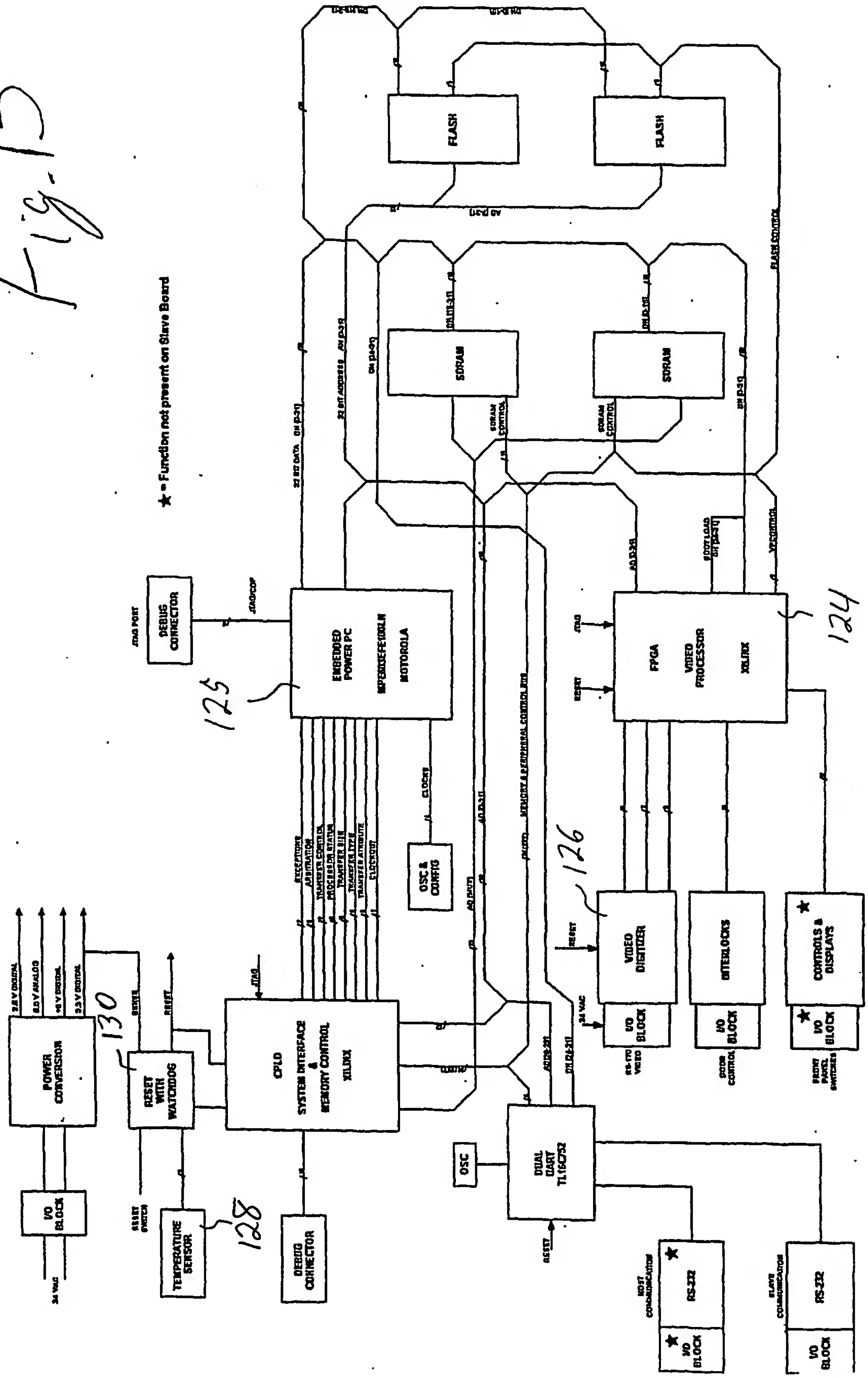

Back side
clear opening
wall
door
121
door columns
Activation Zone
Front side
Zone X Position (Transverse distance)
Zone Y Position (range)
Zone length
Zone width

Figure 14

Fig. 15


★ = Function not present on Slave Board
FLASH
FLASH
SDRAM
SDRAM
EMBEDDED POWER PC
MOTOROLA
DEBUG CONNECTOR
FPGA
VIDEO PROCESSOR
XILINX
VIDEO DIGITIZER
INTERLOCKS
CONTROLS & DISPLAYS
I/O BLOCK
POWER CONVERSION
RESET WITH WATCHDOG
CPLD
SYSTEM INTERFACE & MEMORY CONTROL
XILINX
TEMPERATURE SENSOR
DEBUG CONNECTOR
OSC & CONFIG
OSC
DUAL UART TL16C752
RS-232
RS-232
124
125
126
128
130

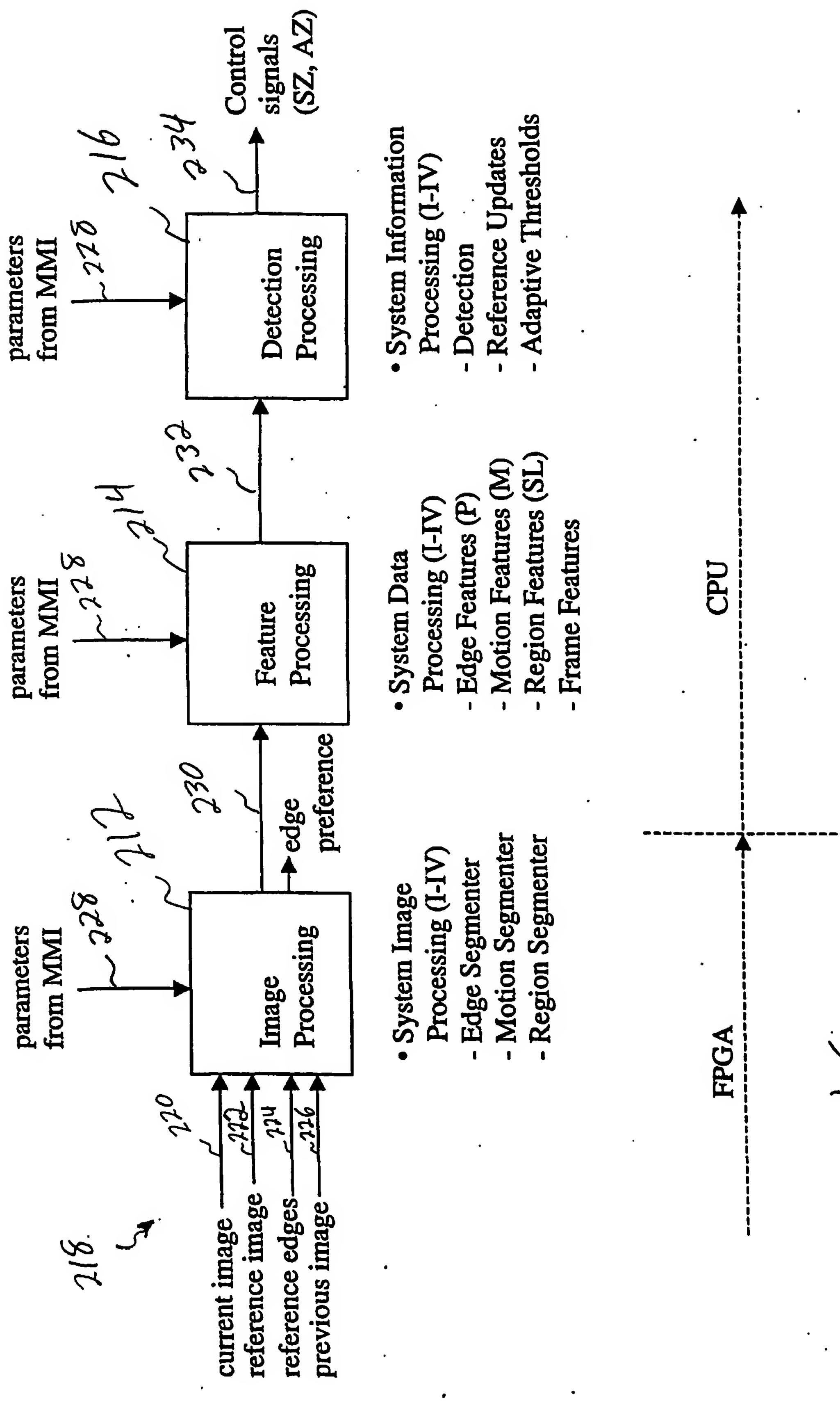

218
current image
reference image
reference edges
previous image
220
222
224
226
parameters from MMI
228
Image Processing
212
edge preference
230
• System Image Processing (I-IV)
- Edge Segmenter
- Motion Segmenter
- Region Segmenter
parameters from MMI
228
Feature Processing
214
232
• System Data Processing (I-IV)
- Edge Features (P)
- Motion Features (M)
- Region Features (SL)
- Frame Features
parameters from MMI
228
Detection Processing
216
234
Control signals (SZ, AZ)
• System Information Processing (I-IV)
- Detection
- Reference Updates
- Adaptive Thresholds
FPGA
CPU

Figure 16

System Initializations I

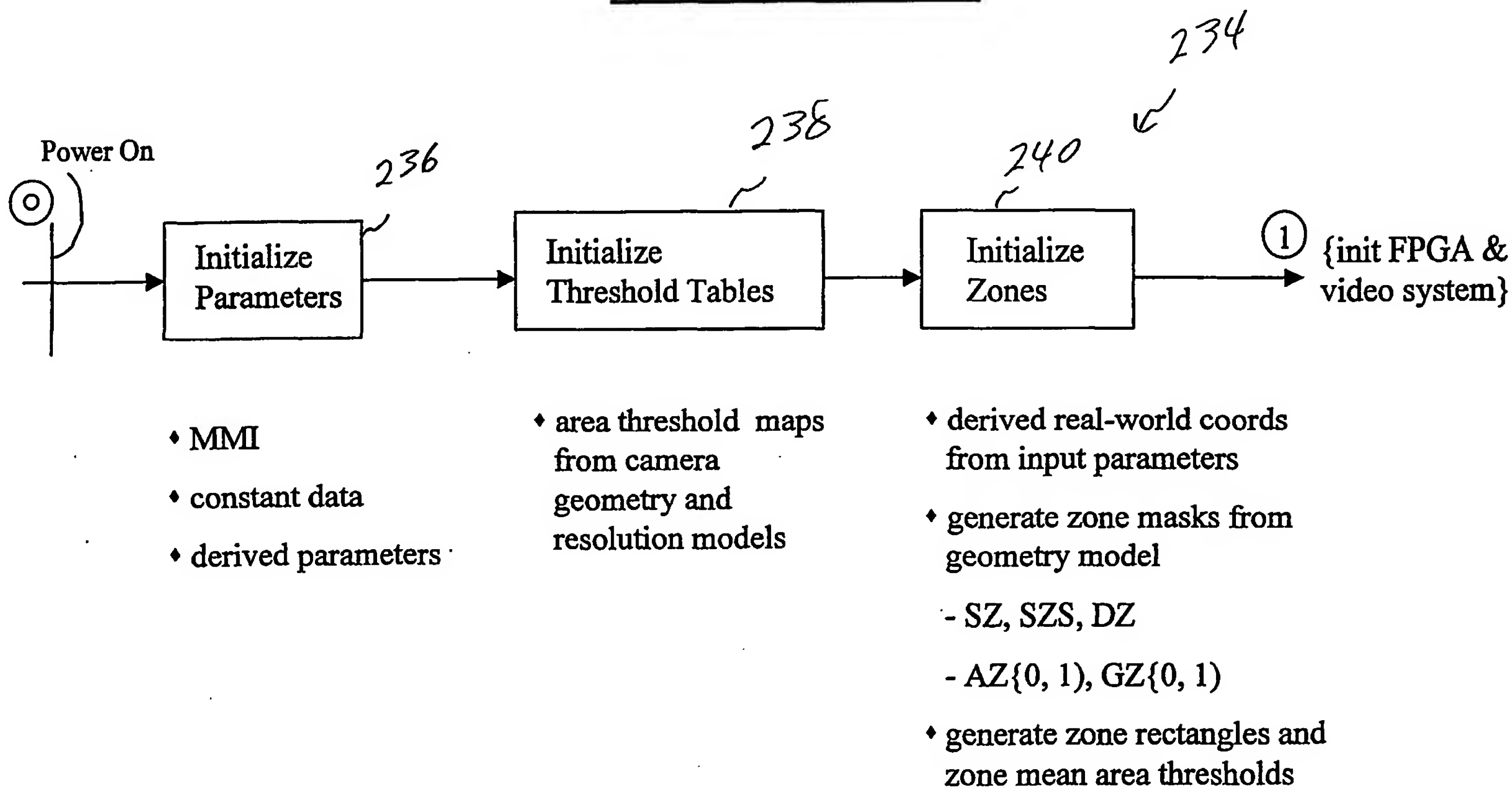
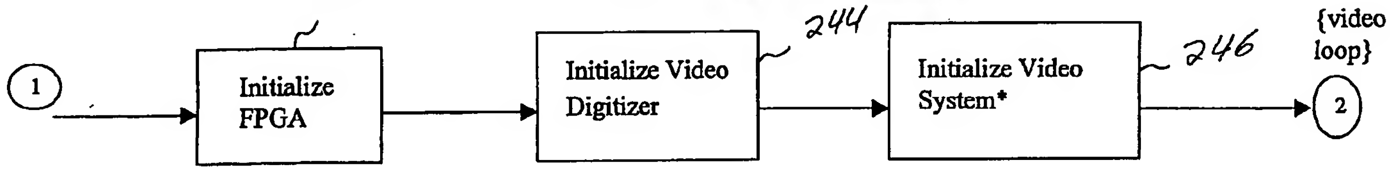


Figure17

System Initializations II



- init FPGA serial I/O
  - threshold inputs {1,2,3}
  - initial LED state {5,6}
- init CSR†
  - set all interrupts
- init Buffer pointers
  - Banks {0,1}; A,R,GER
- select ping/pong Bank Ø

- build & send FPGA serial KS1022 data {4}
  - 3 byte frame instructions

- use CSR to select Bank Ø buffer pointers
- use CRS to set capture video, wait for capture complete interrupt
- CPU unit references
  - copy B→A, B→R
  - Sobel(B) →GER
  - copy GER →Archive Edges
- use CSR to set process video, wait for process complete interrupt
- magnify GER based on clutter suppress value
- init frame Analysis Bank Ø histogram from FPGA output
- init Bank Ø region, conflict & black counts from FPGA output
- init Frame Analysis data
- calculate edge & grey level statistics in defined zones

Figure 18

† CSR = FPGA Control/Status Register

* without ACC

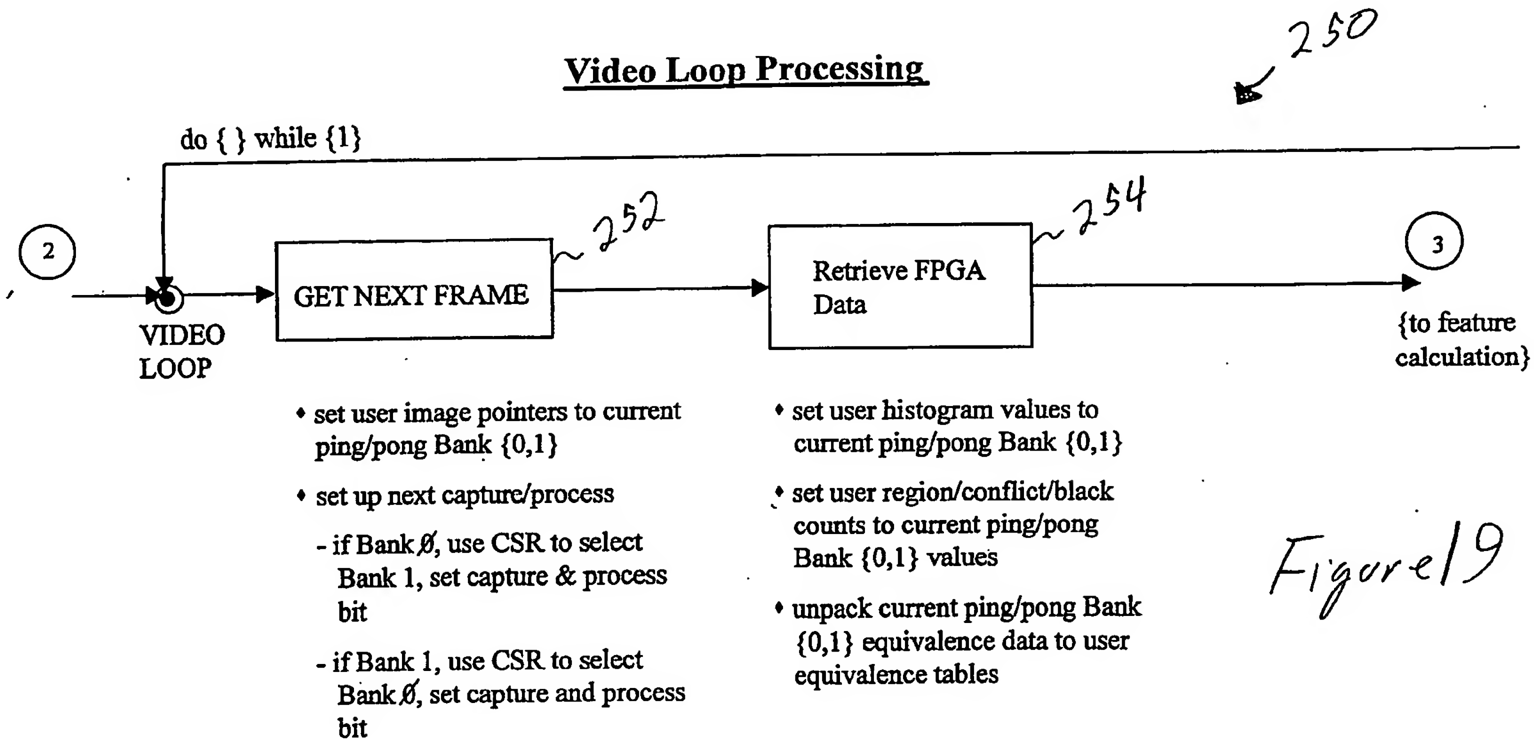


Figure 19

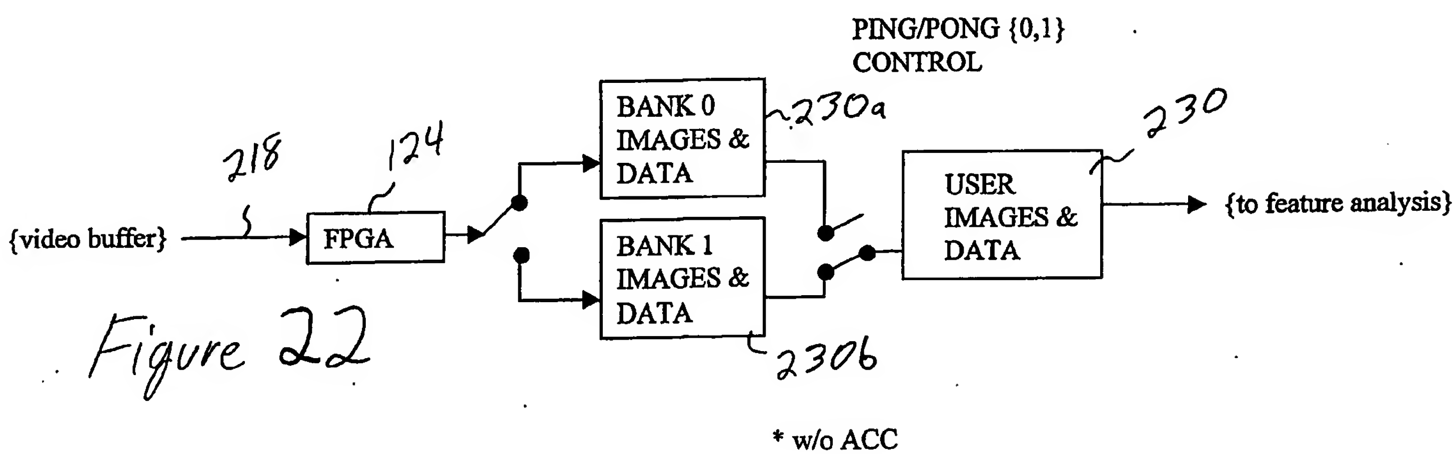


Figure 22

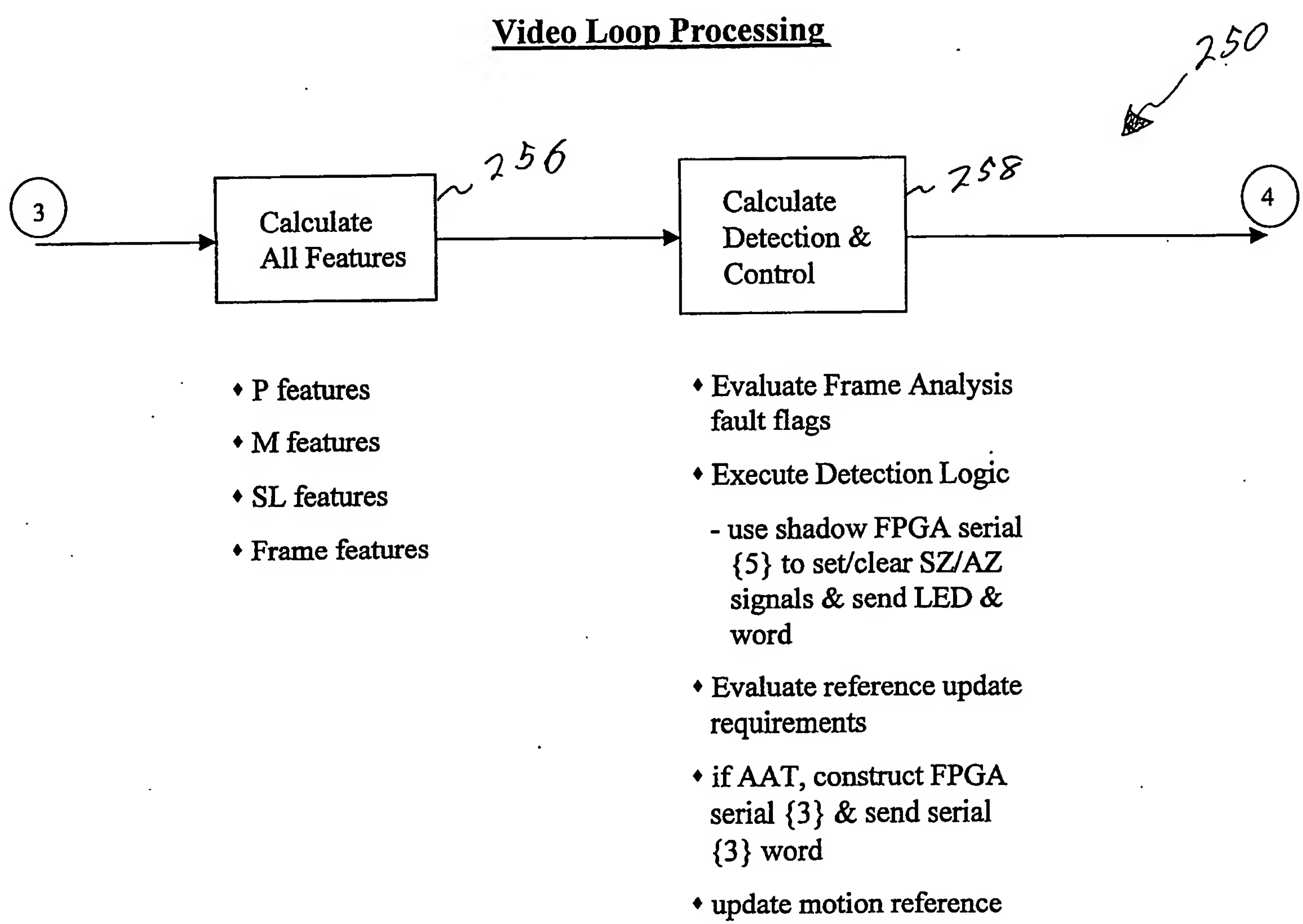

Video Loop Processing
250
3
Calculate All Features
256
Calculate Detection & Control
258
4
♦ P features
♦ M features
♦ SL features
♦ Frame features
♦ Evaluate Frame Analysis fault flags
♦ Execute Detection Logic
- use shadow FPGA serial {5} to set/clear SZ/AZ signals & send LED & word
♦ Evaluate reference update requirements
♦ if AAT, construct FPGA serial {3} & send serial {3} word
♦ update motion reference

Figure 20

Video Loop Processing

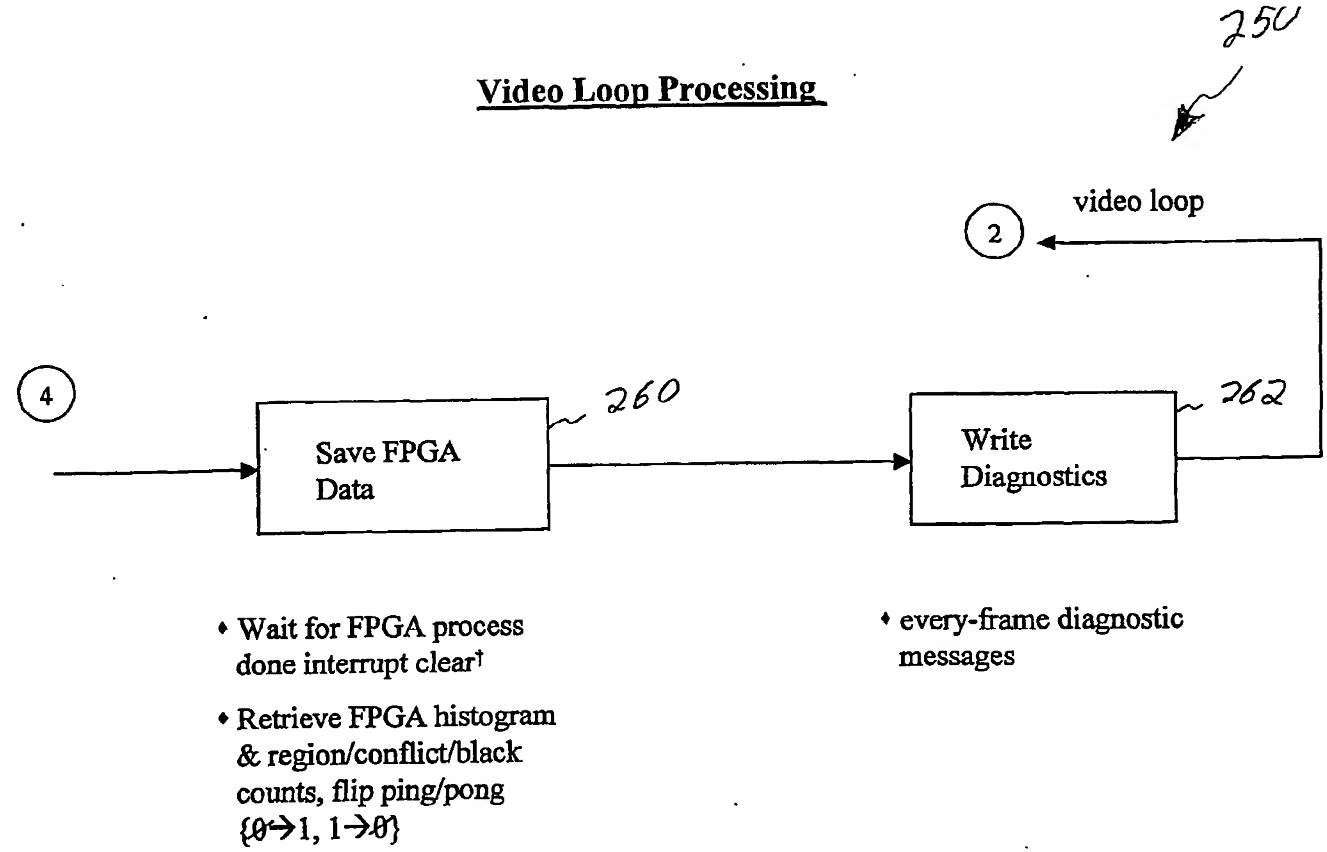


Figure 21

†(FPGA processing time less than CPU feature processing)

System Ping/Pong: Initialization

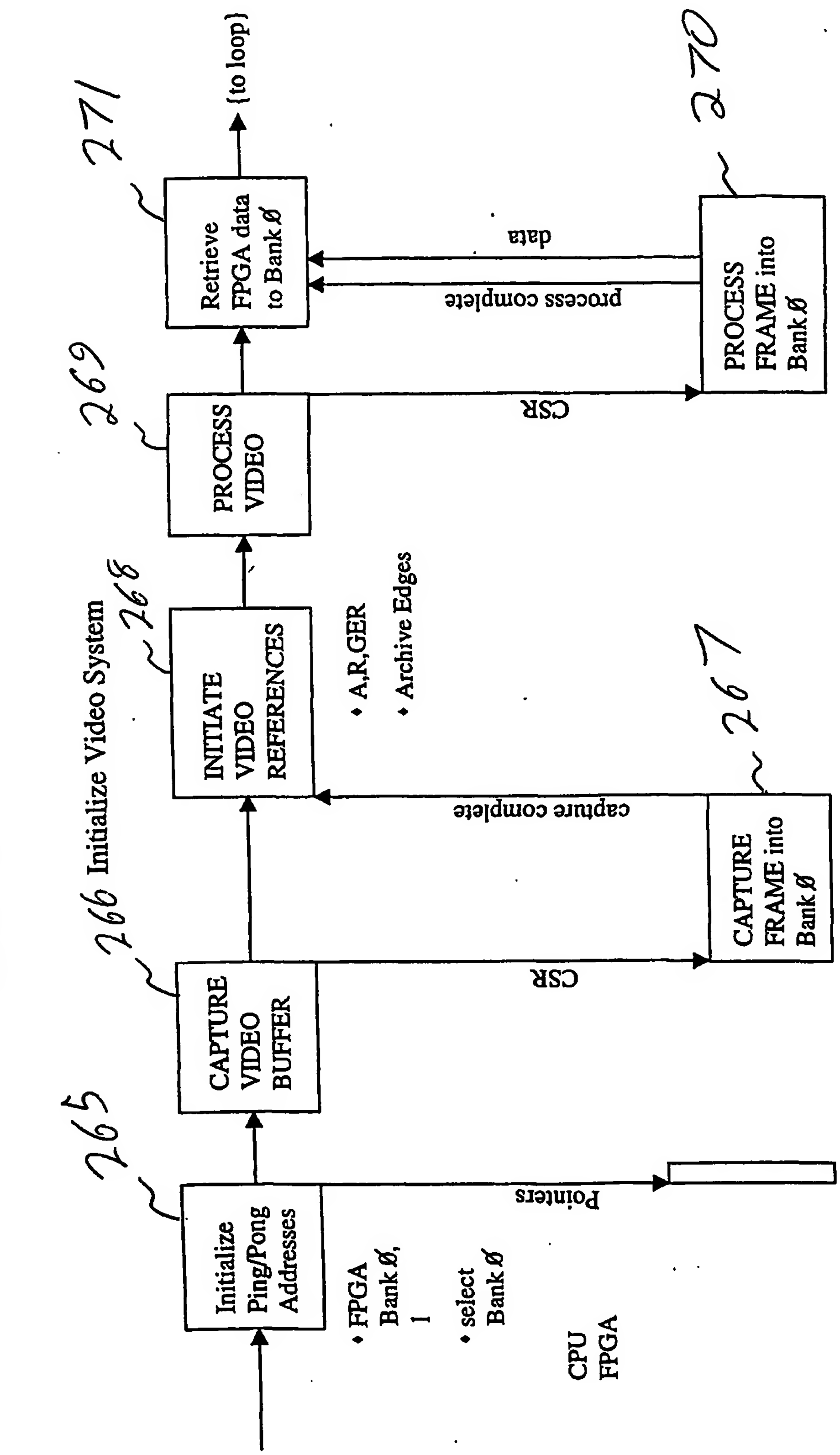
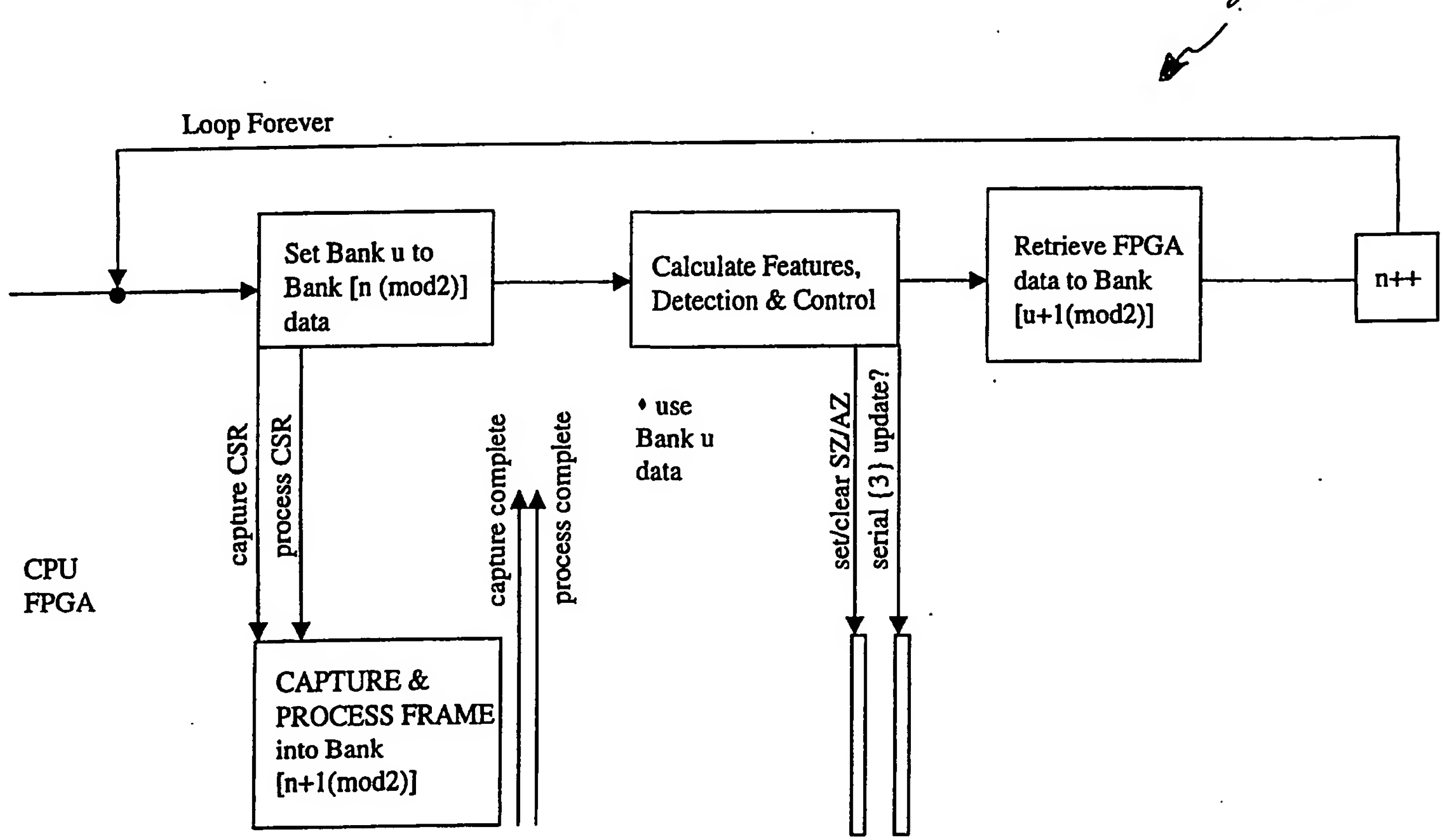


Figure 23

System Ping/Pong: Loop



N = frame number

Figure 24

ACC In Initialization

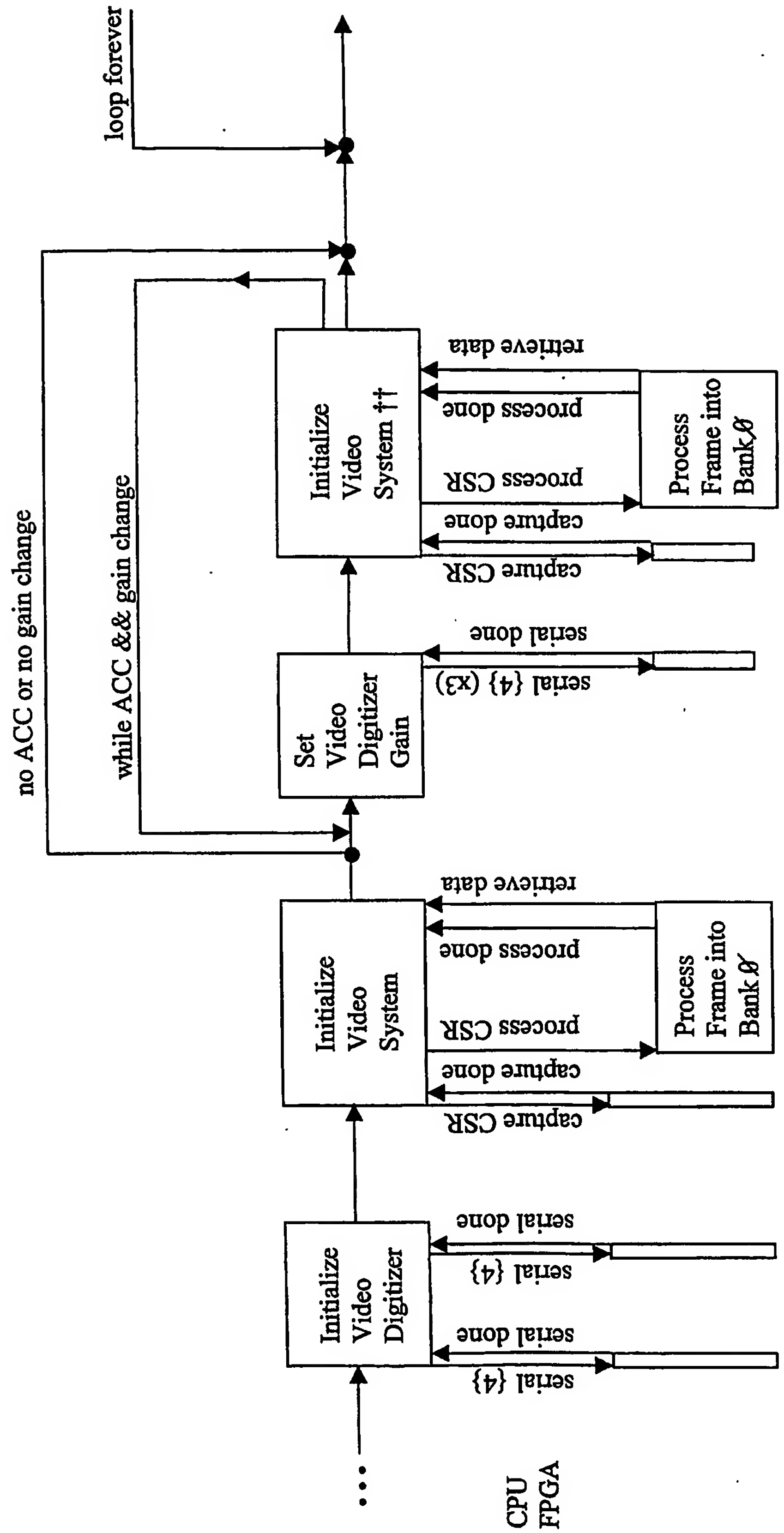


Figure 25

†† except, do not initialize zone statistics

ACC in Video Loop

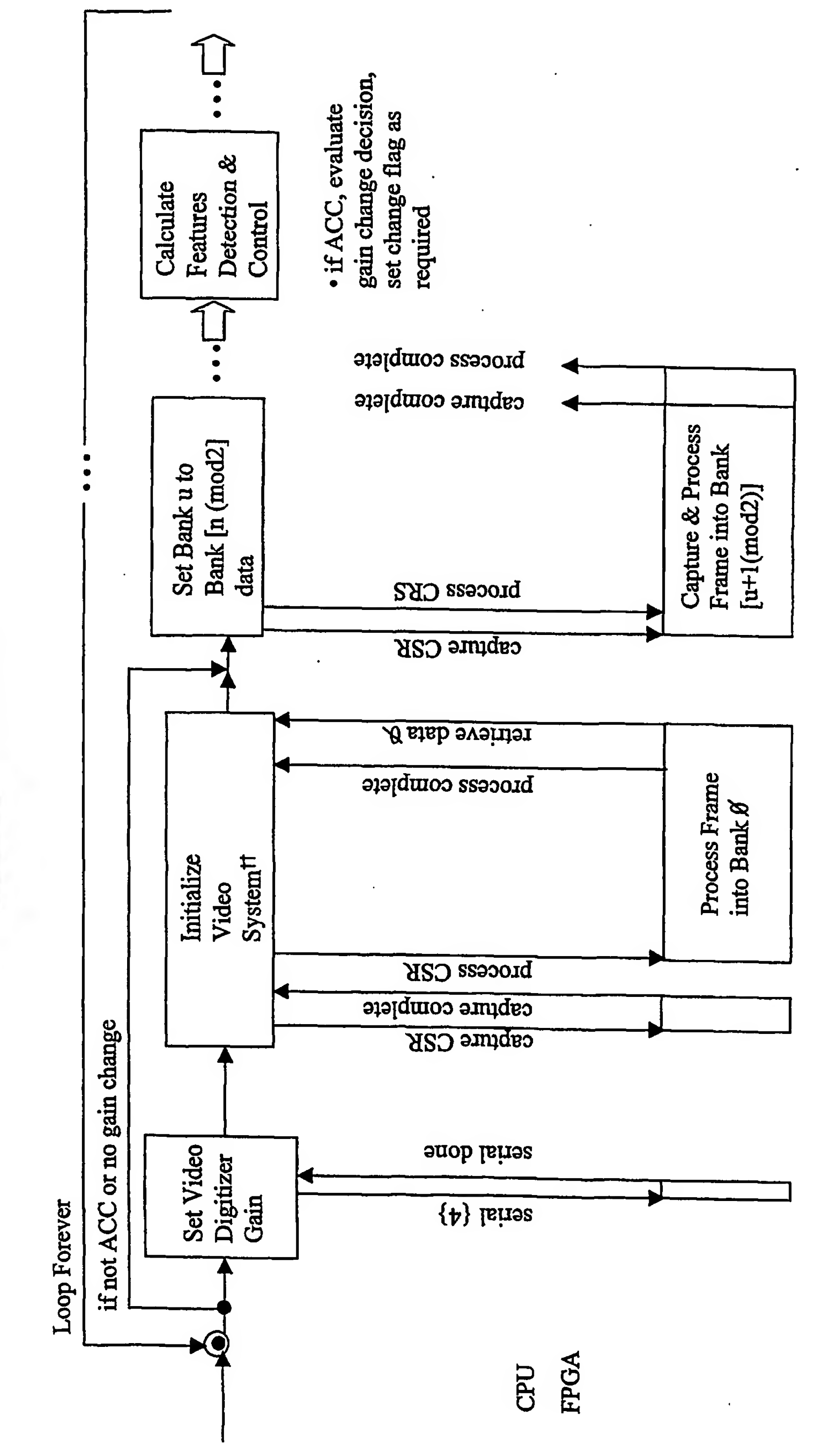
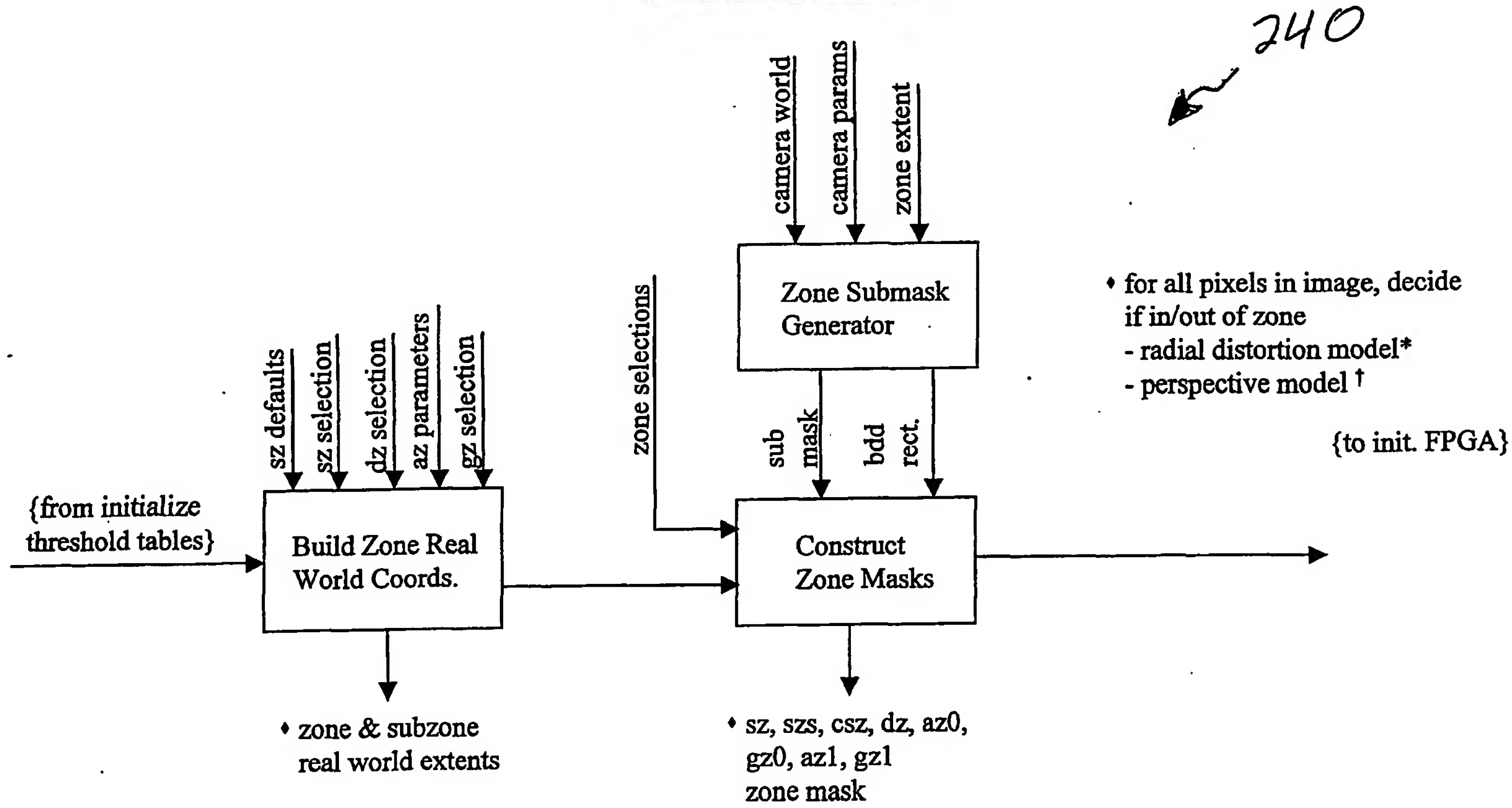


Figure 26

†† see description on "System Ping/Pong: Initialization"

System Initialization:

Initialize Zones



NOTES: *lens radial distortion parameters determined via laboratory procedure

†inverse homogeneous coordinates, pin-hole camera model

Figure 27

System Initialization:

Initialize Threshold Tables

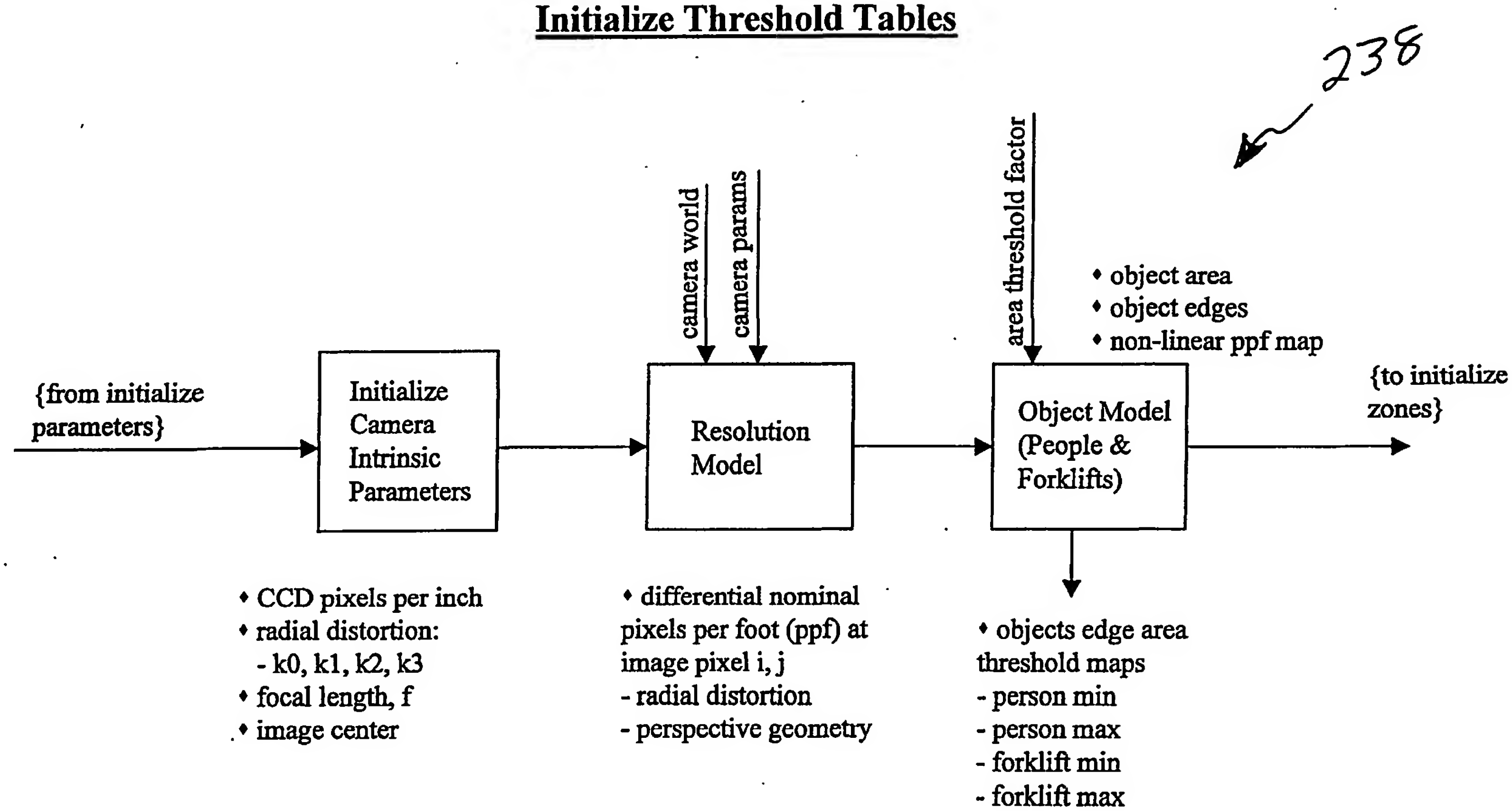


Figure 28

System Image Processing I:

Edge Detector

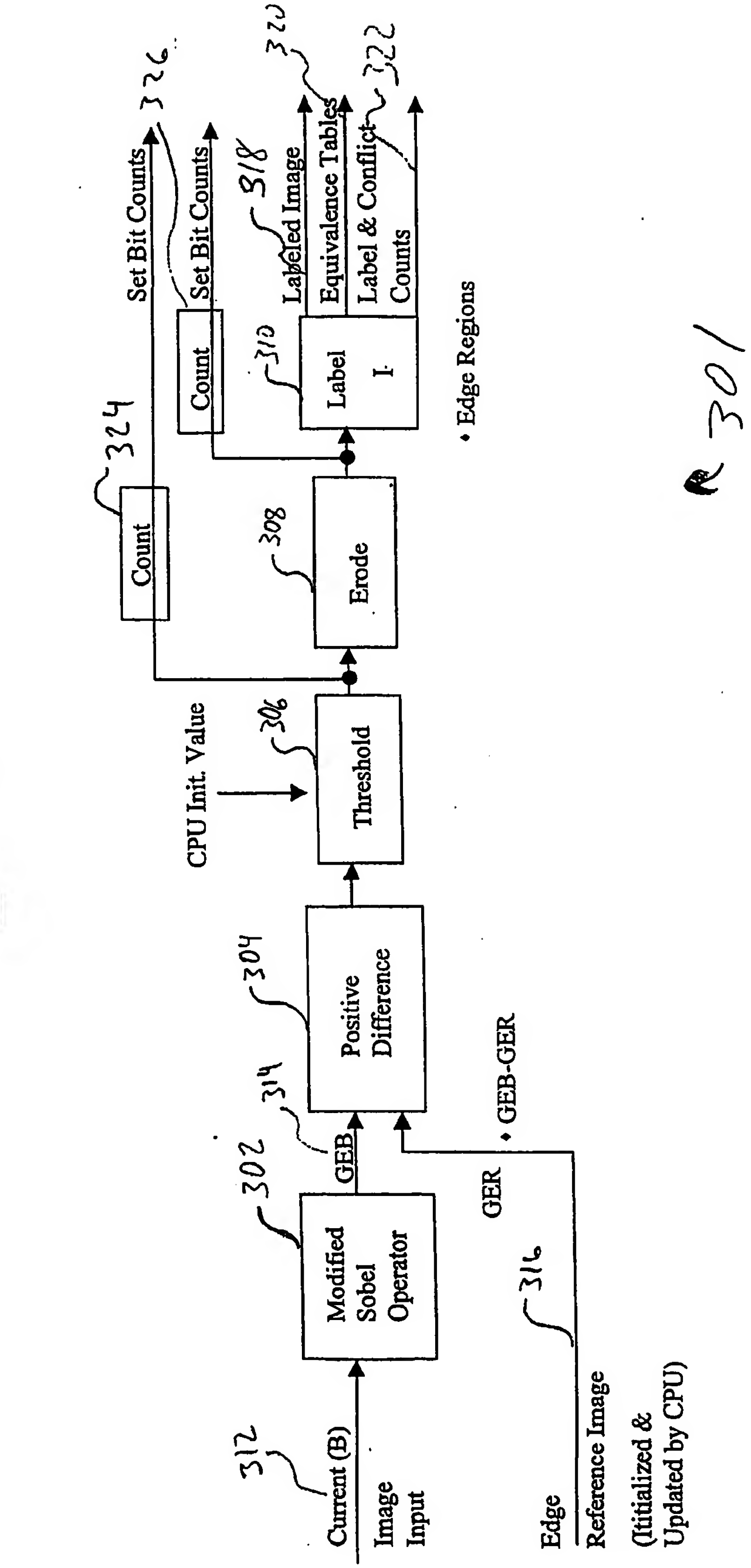


Figure 29

System Image Processing II:

Motion Detection Using Regions

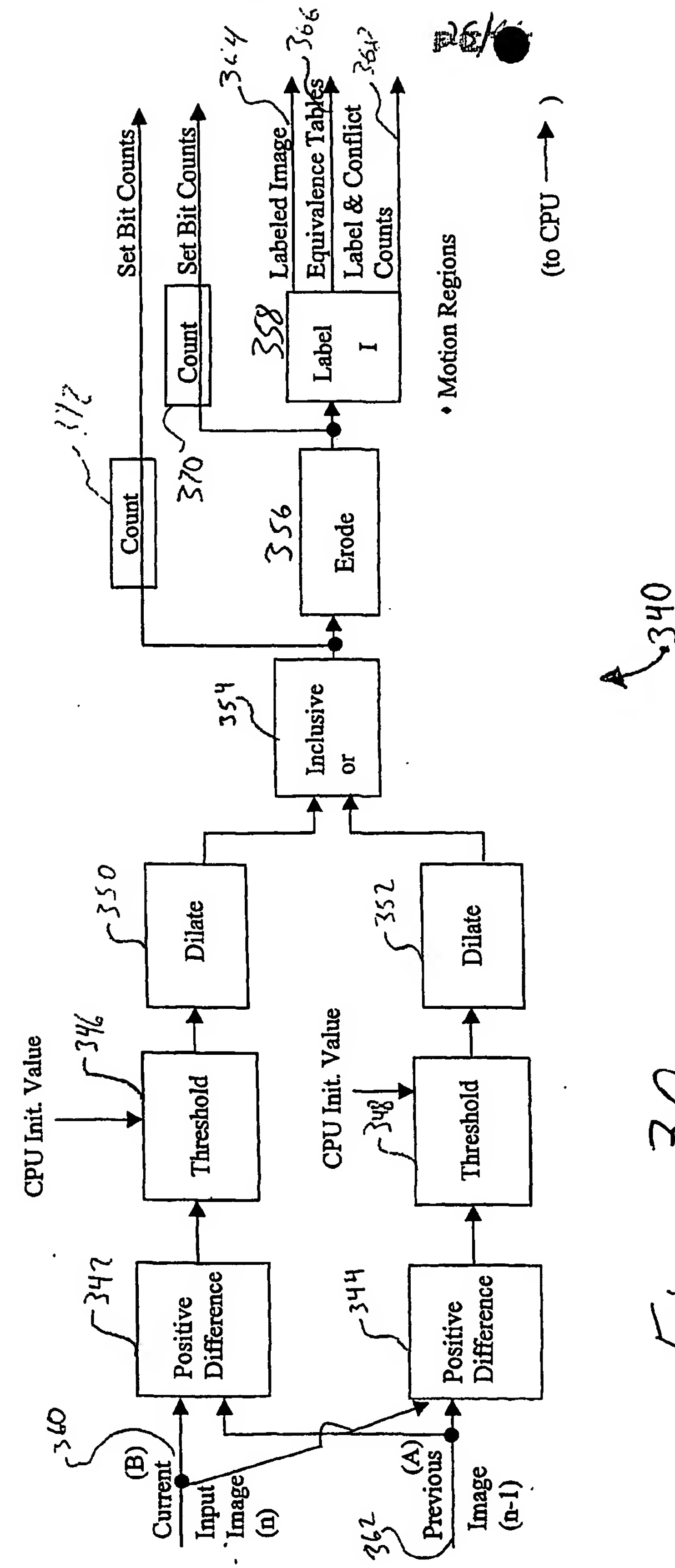
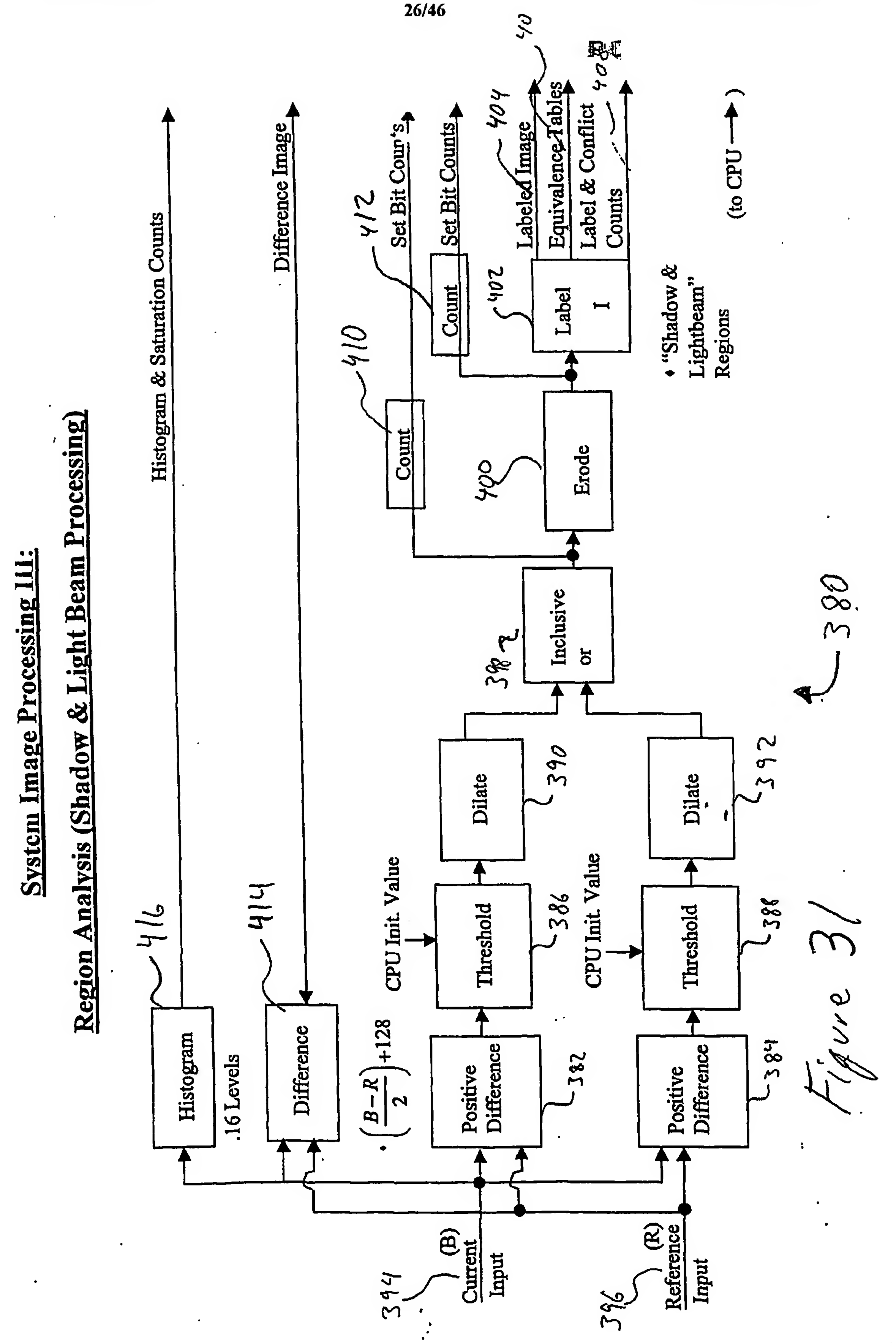


Figure 30


System Image Processing III:
Region Analysis (Shadow & Light Beam Processing)
Histogram & Saturation Counts
Difference Image
Set Bit Coun's
Set Bit Counts
Labeled Image
Equivalence Tables
Label & Conflict Counts
(to CPU)
Histogram
.16 Levels
Difference
$\left(\frac{B-R}{2}\right)+128$
Positive Difference
Threshold
CPU Init. Value
Dilate
Inclusive or
Count
Erode
Label I
• "Shadow & Lightbeam" Regions
(B) Current Input
(R) Reference Input
394
396
382
384
386
388
390
392
398
400
402
404
410
412
414
416
380
Figure 31

System Image Processing IV:

Motion Detection Using Edges

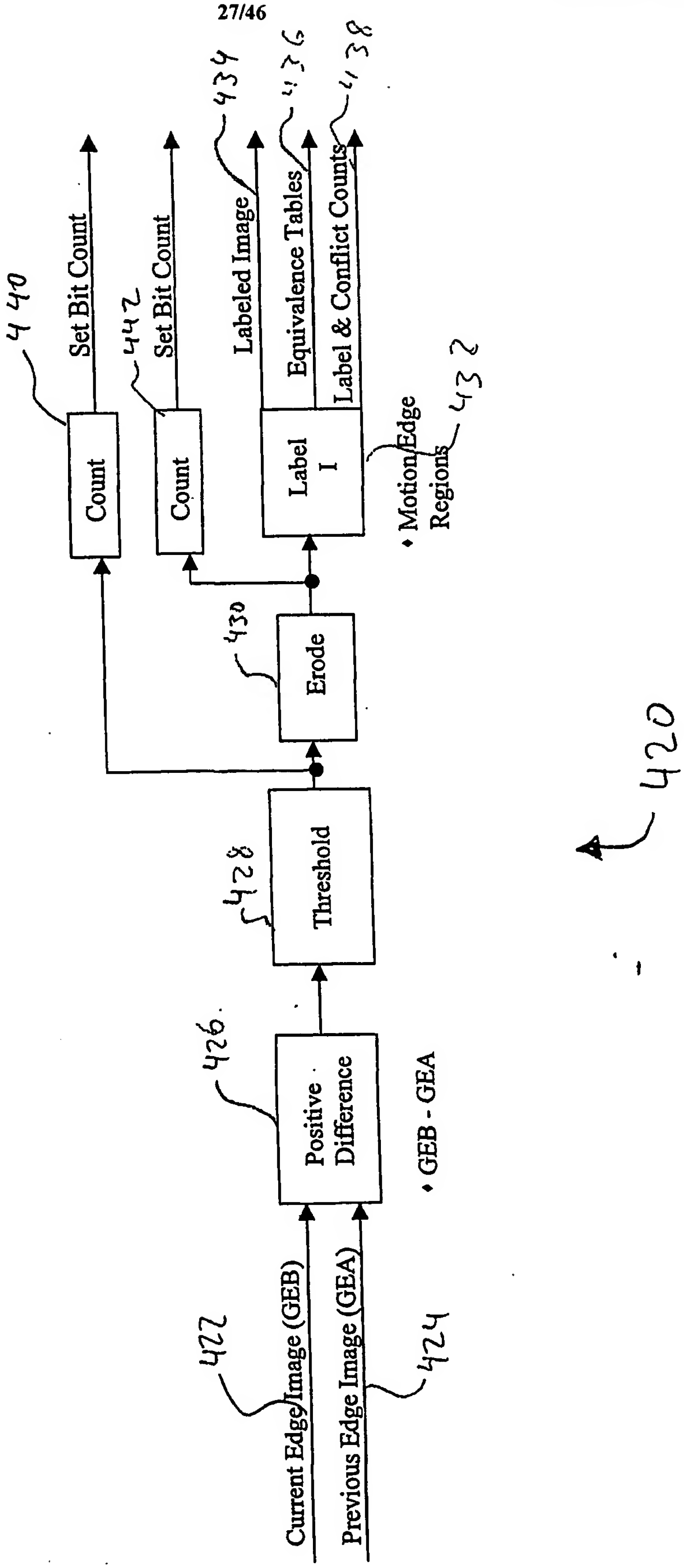


Figure 32

System Data Processing I:

Feature Generation

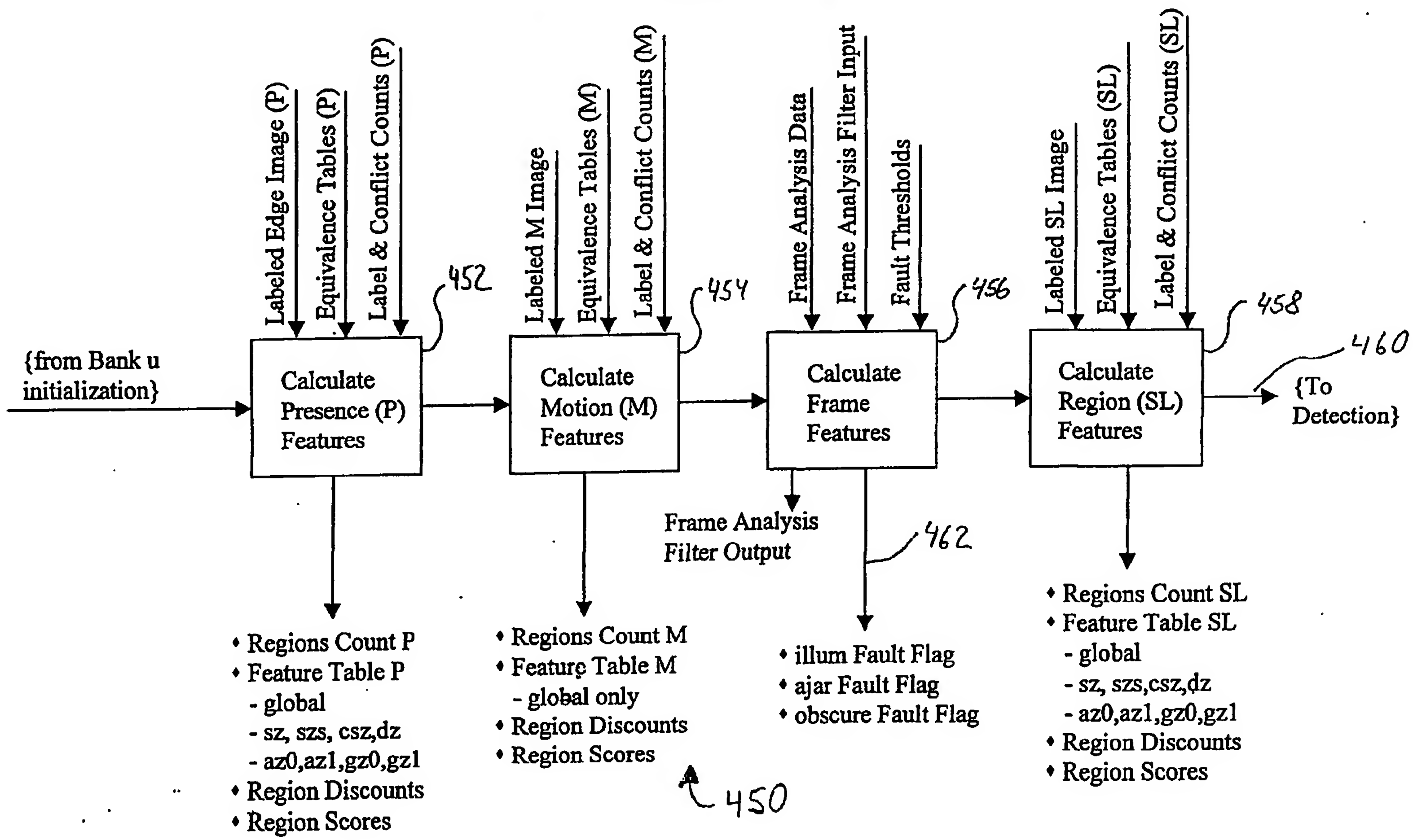


Figure 33

System Data Processing II:

Calculate Presence (Edge) Features

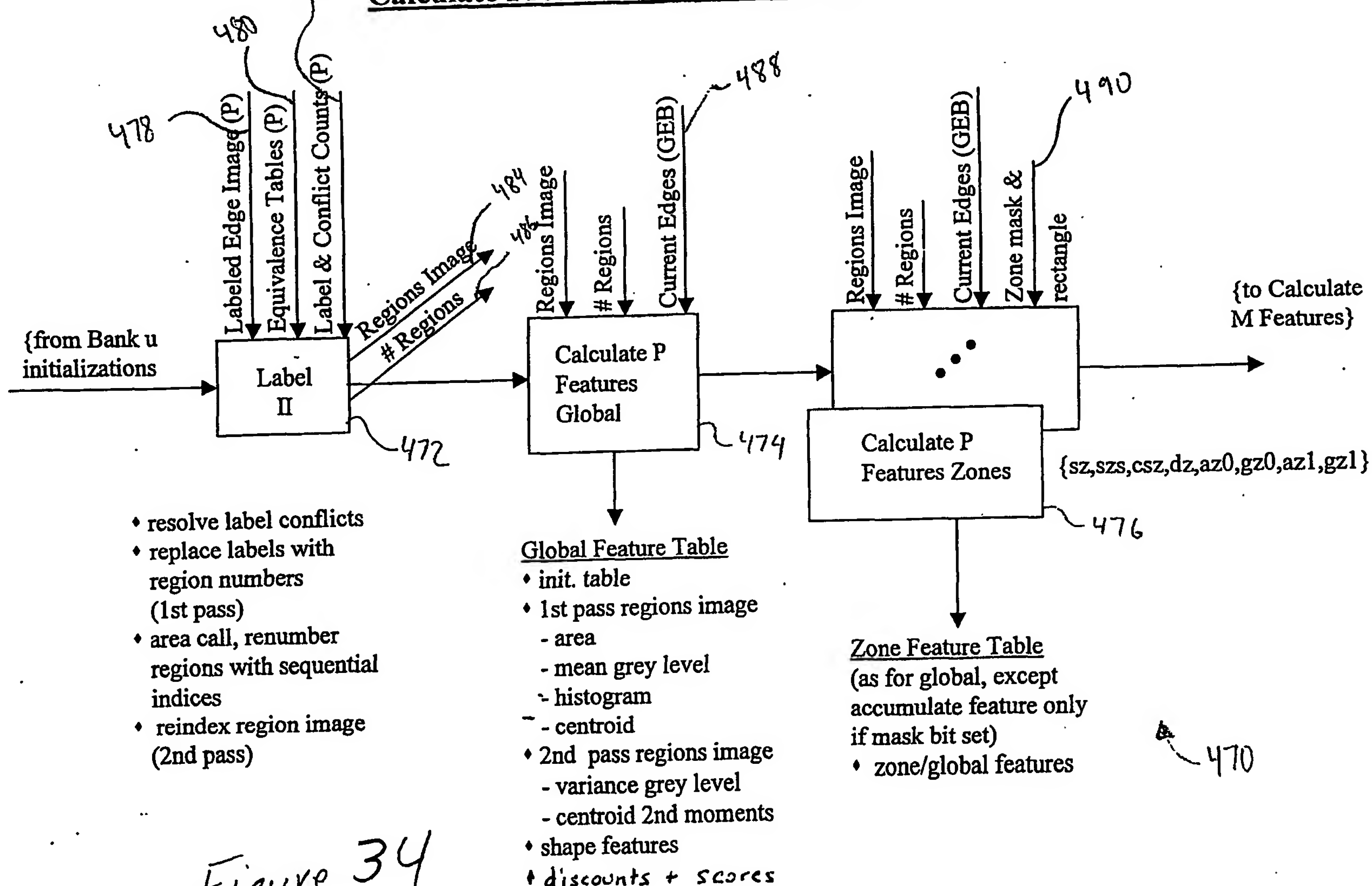


Figure 34

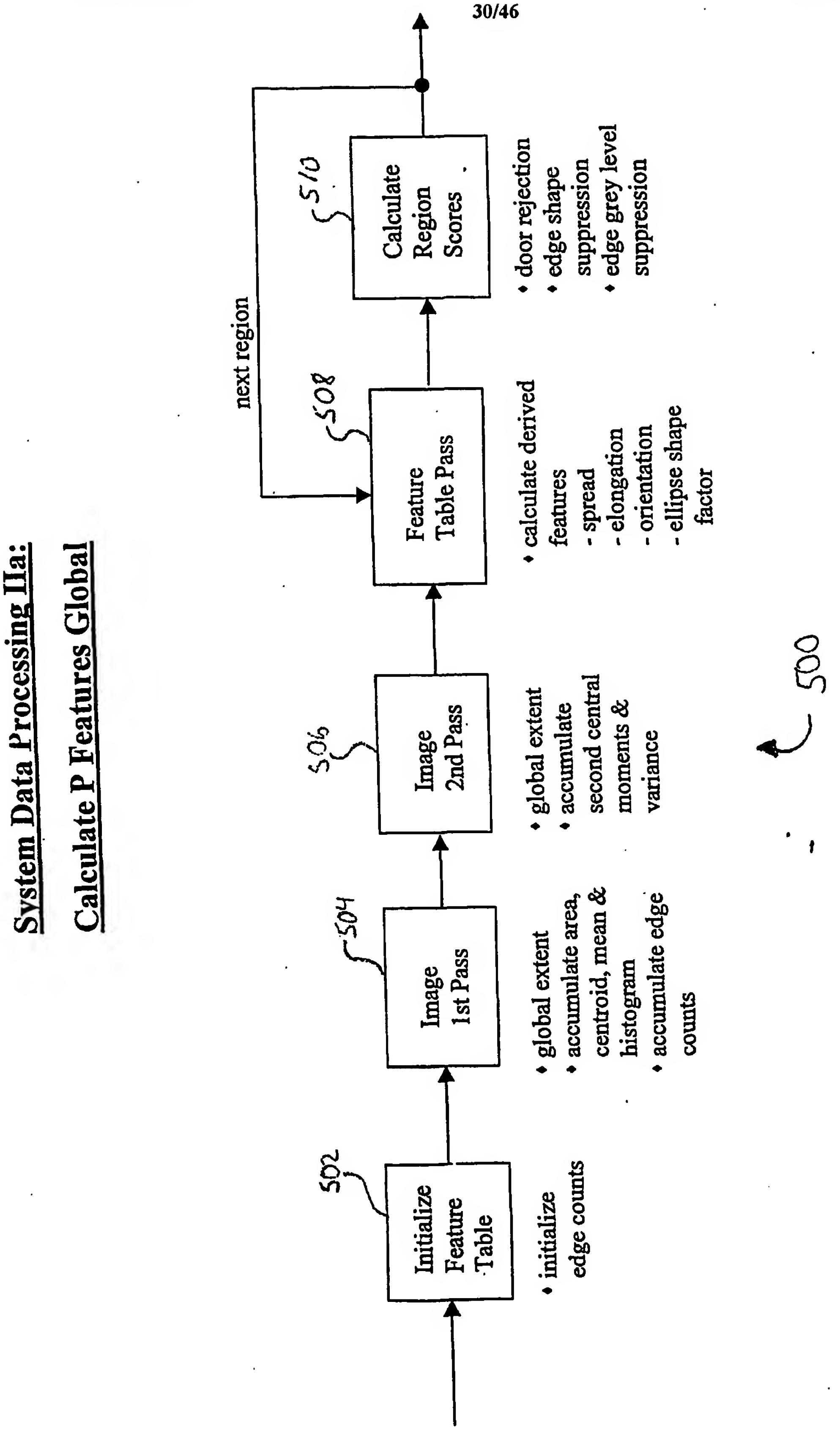

System Data Processing IIa:
Calculate P Features Global
502
Initialize Feature Table
• initialize edge counts
504
Image 1st Pass
• global extent
• accumulate area, centroid, mean & histogram
• accumulate edge counts
506
Image 2nd Pass
• global extent
• accumulate second central moments & variance
508
Feature Table Pass
• calculate derived features
- spread
- elongation
- orientation
- ellipse shape factor
510
Calculate Region Scores
• door rejection
• edge shape suppression
• edge grey level suppression
next region
500

Figure 35

System Data Processing IIb:

Calculate P Features Zones

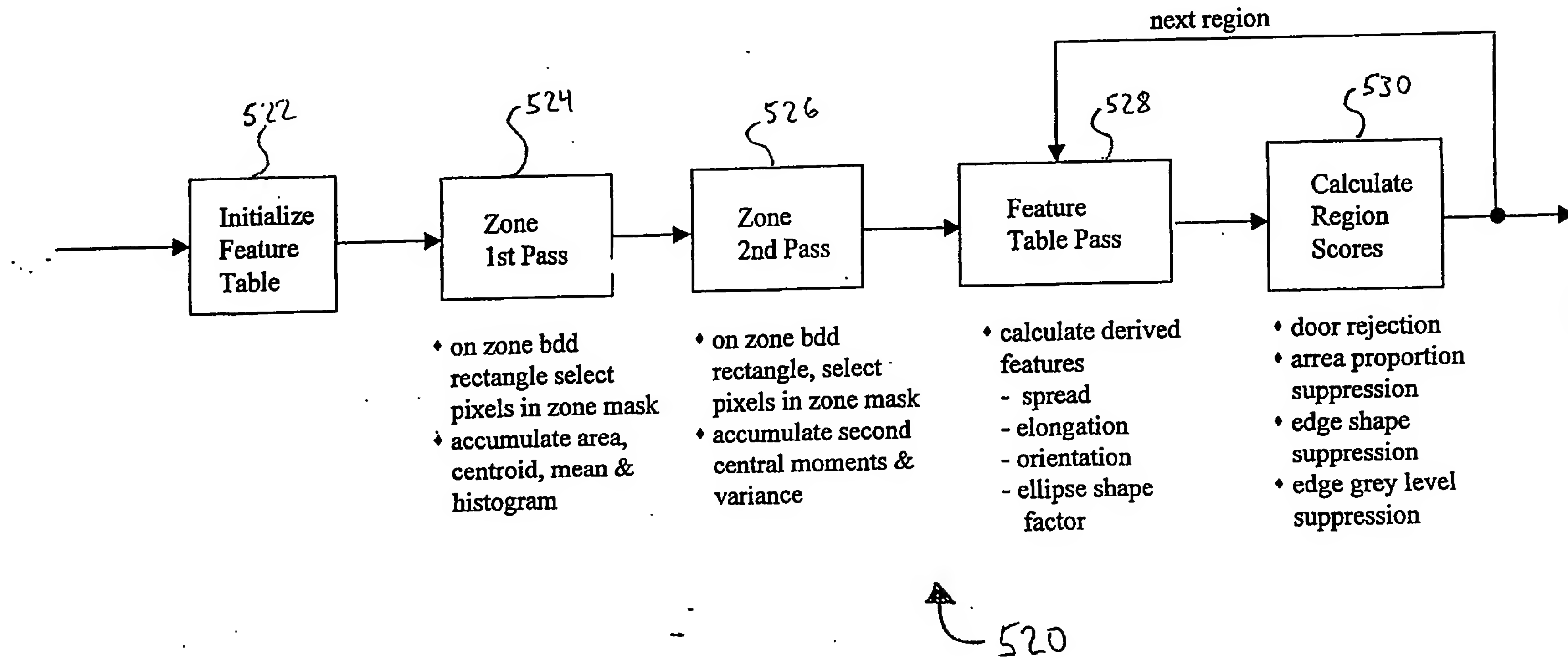
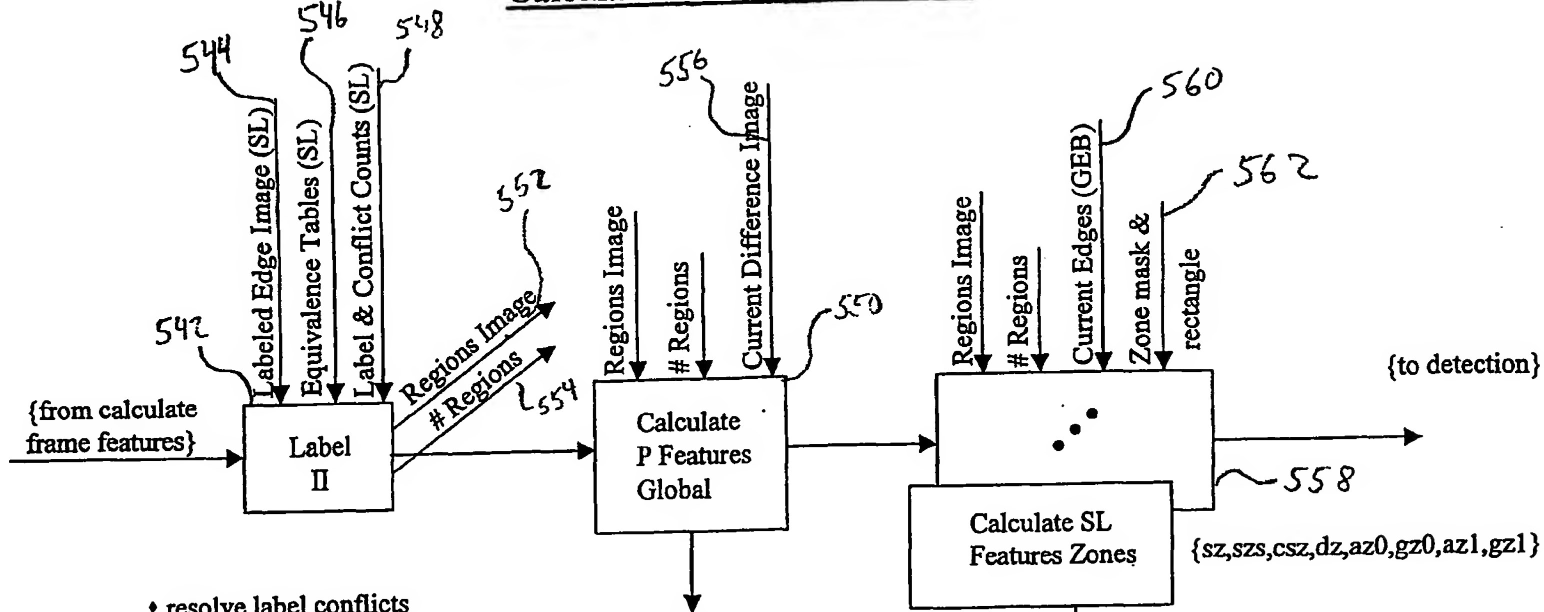


Figure 36

System Data Processing III:

Calculate SL Region Features



- resolve label conflicts
- replace labels with region numbers (1st pass)
- area call, renumber regions with sequential indices
- reindex region image (2nd pass)

Global Feature Table
- init. table
- 1st pass regions image
  - area
  - mean grey level
  - histogram
  - centroid
- 2nd pass regions image
  - variance grey level
  - centroid 2nd moments
- shape features
- discounts + scores

Zone Feature Table
(as for global, except accumulate feature only if mask bit set)
- SL discounts
- discounted SL score

540

Figure 37

System Data Processing IIIa:

Calculate SL Features Global

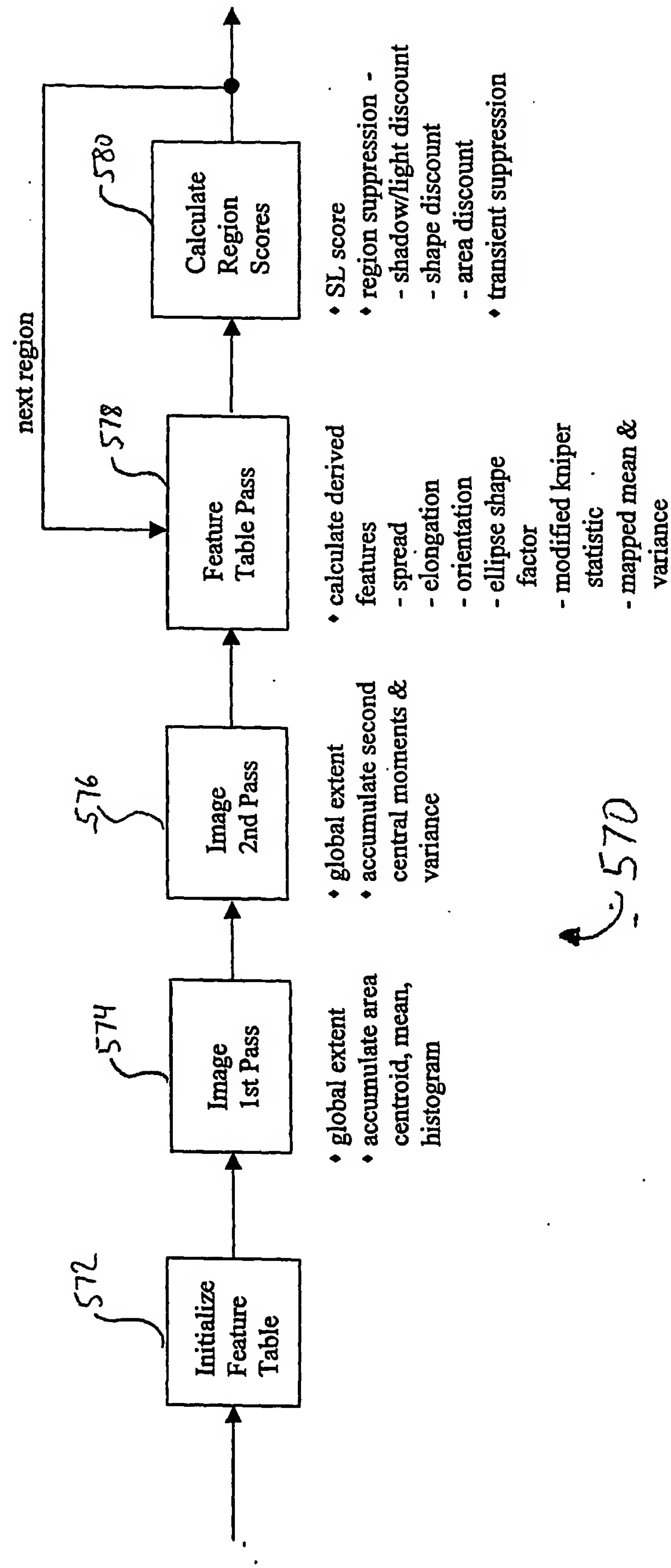


Figure 38

System Data Processing IIIb:

Calculate SL Features Zones

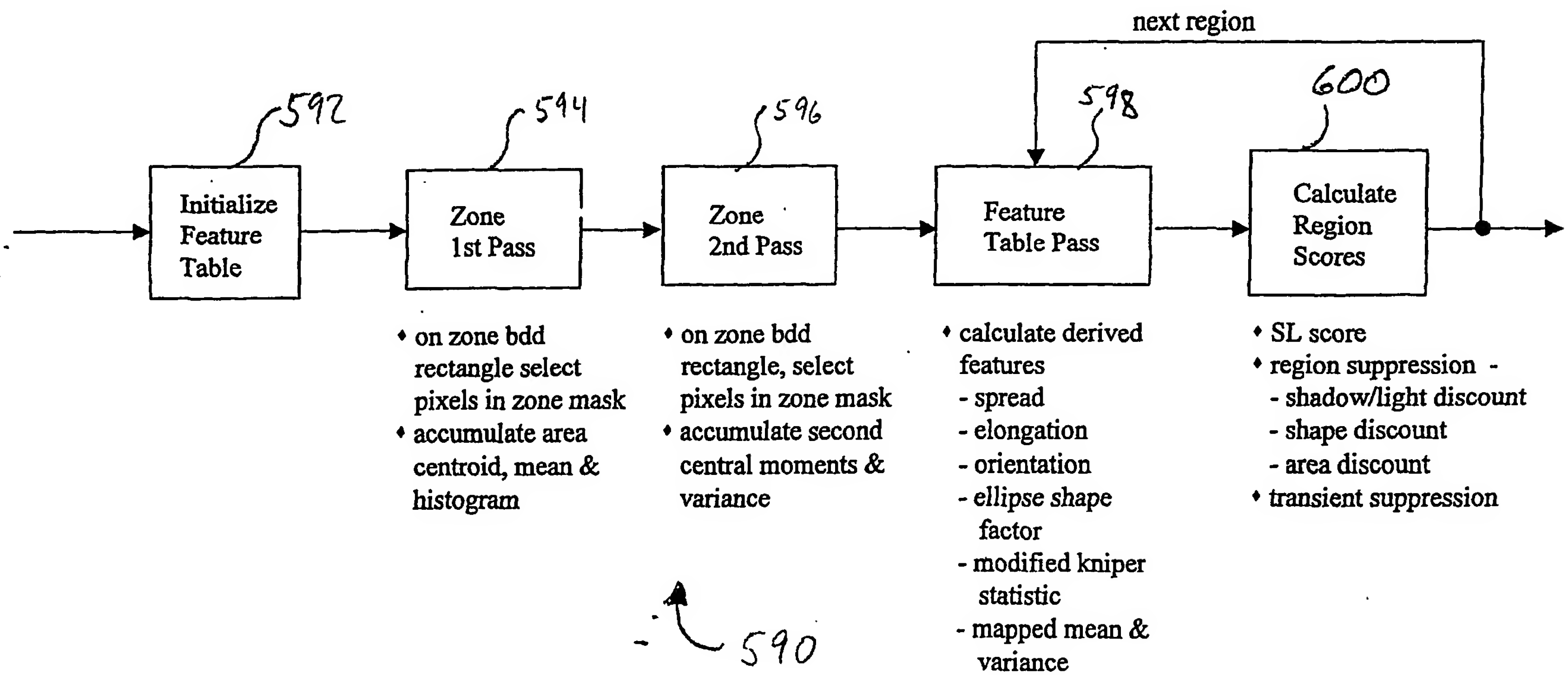


Figure 39

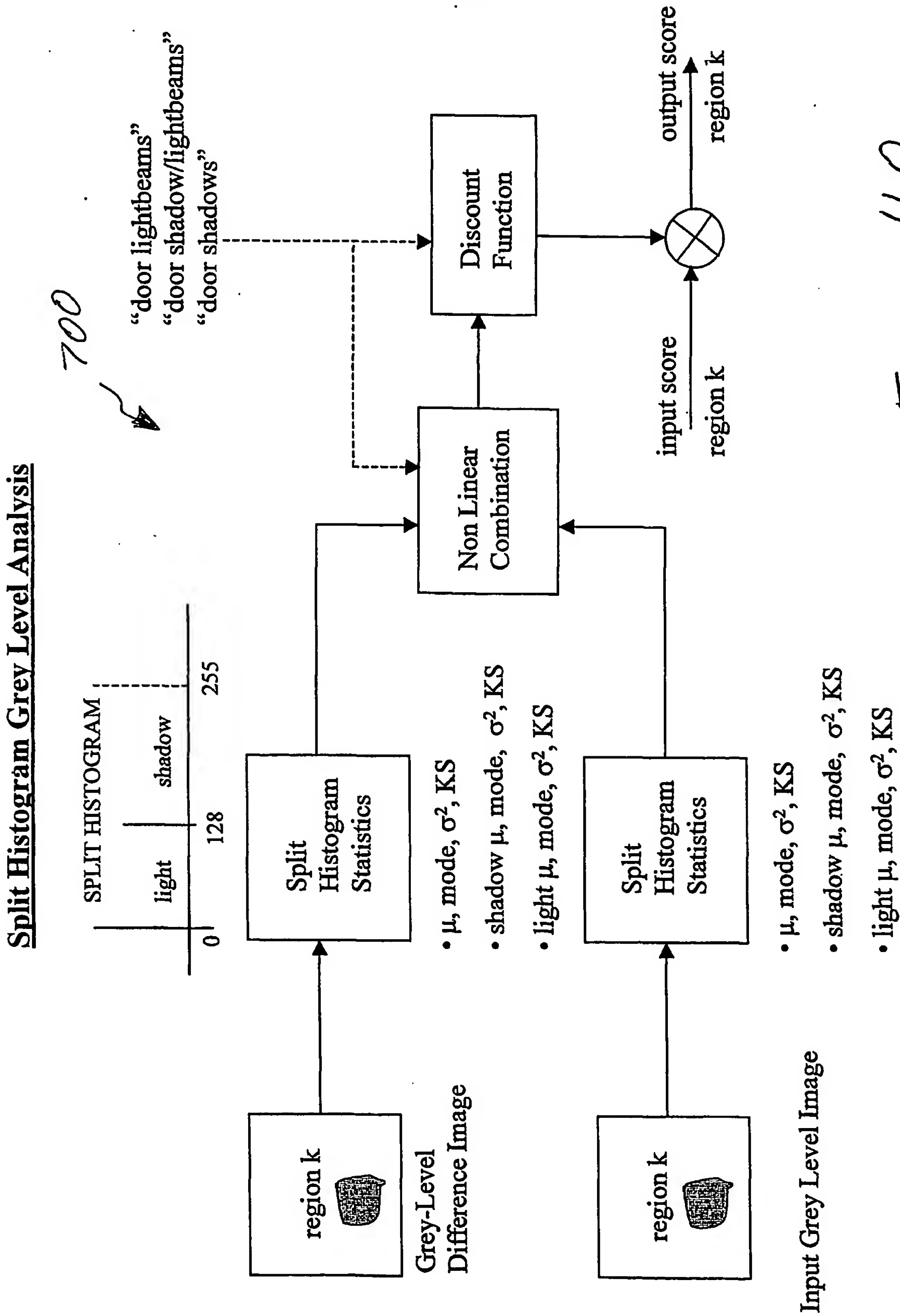

Split Histogram Grey Level Analysis
700
SPLIT HISTOGRAM
light
shadow
0
128
255
"door lightbeams"
"door shadow/lightbeams"
"door shadows"
region k
Grey-Level Difference Image
Split Histogram Statistics
• μ, mode, σ², KS
• shadow μ, mode, σ², KS
• light μ, mode, σ², KS
region k
Input Grey Level Image
Split Histogram Statistics
• μ, mode, σ², KS
• shadow μ, mode, σ², KS
• light μ, mode, σ², KS
Non Linear Combination
Discount Function
input score region k
output score region k

Figure 40

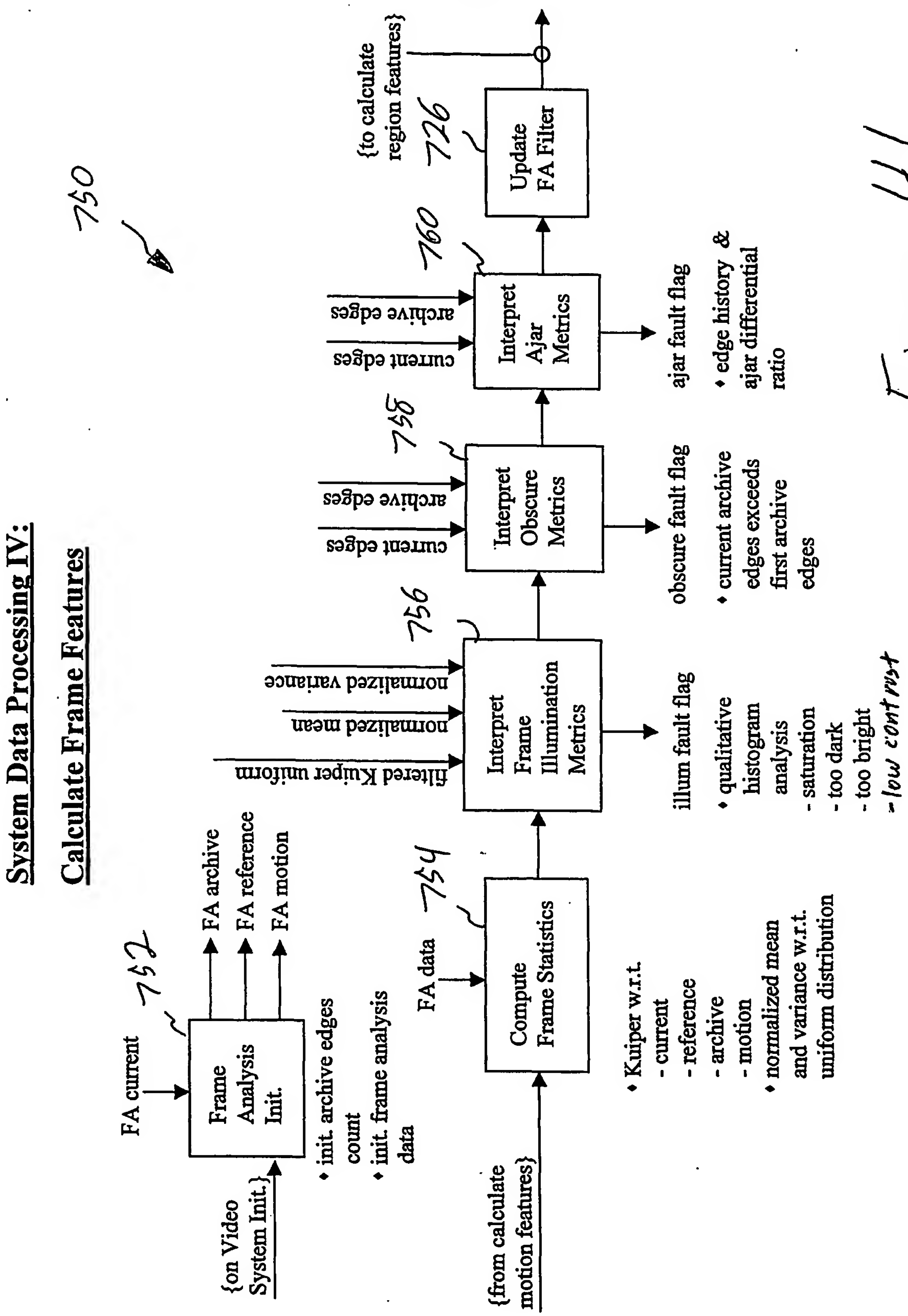

System Data Processing IV:
Calculate Frame Features
750
FA current
Frame Analysis Init.
752
{on Video System Init.}
FA archive
FA reference
FA motion
• init. archive edges count
• init. frame analysis data
FA data
Compute Frame Statistics
754
{from calculate motion features}
• Kuiper w.r.t.
- current
- reference
- archive
- motion
• normalized mean and variance w.r.t. uniform distribution
filtered Kuiper uniform
normalized mean
normalized variance
Interpret Frame Illumination Metrics
756
illum fault flag
• qualitative histogram analysis
- saturation
- too dark
- too bright
- low contrast
current edges
archive edges
Interpret Obscure Metrics
758
obscure fault flag
• current archive edges exceeds first archive edges
current edges
archive edges
Interpret Ajar Metrics
760
ajar fault flag
• edge history & ajar differential ratio
Update FA Filter
726
{to calculate region features}

Figure 41

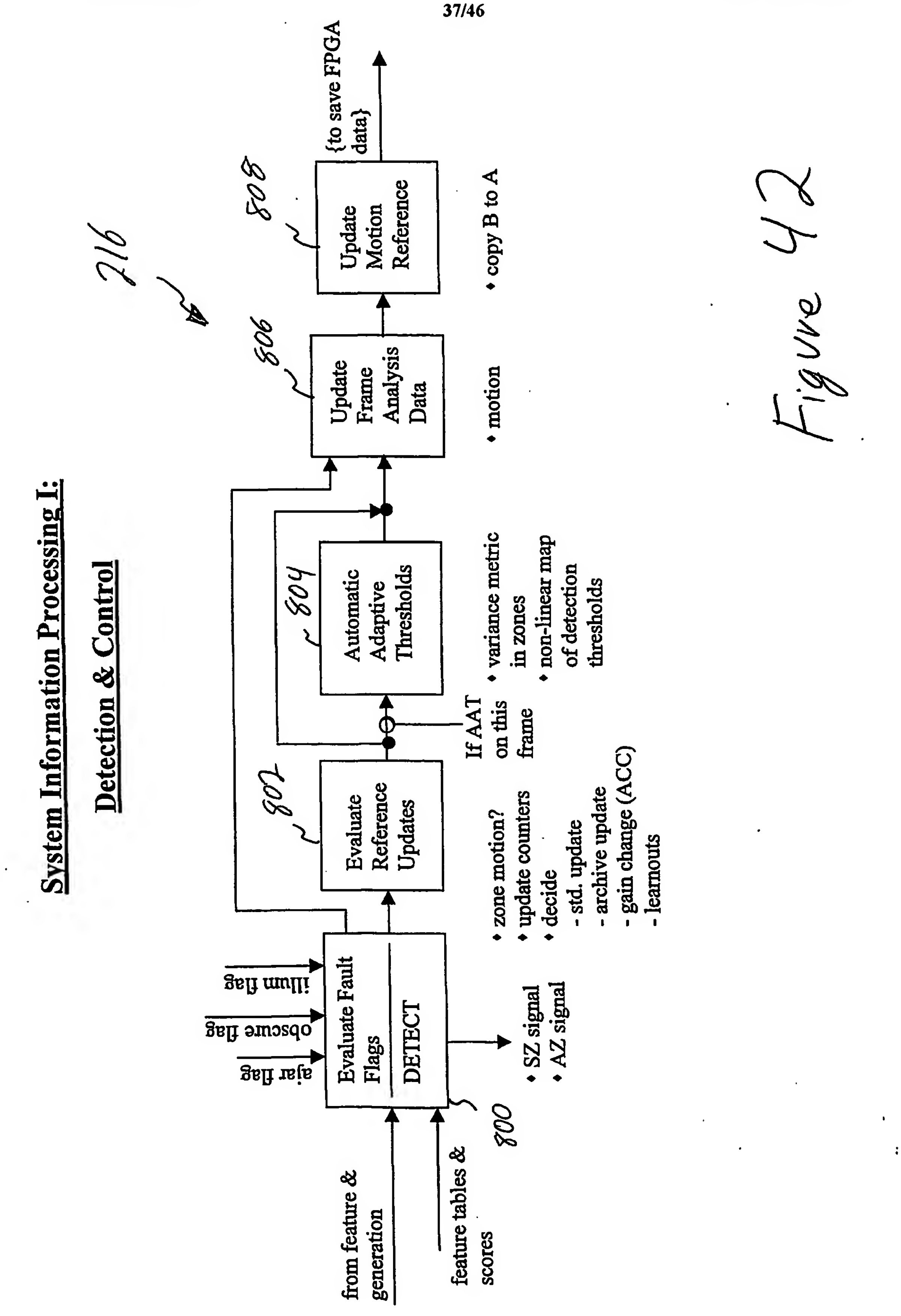

System Information Processing I:
Detection & Control
216
from feature & generation
feature tables & scores
ajar flag
obscure flag
illum flag
Evaluate Fault Flags
DETECT
800
• SZ signal
• AZ signal
Evaluate Reference Updates
802
• zone motion?
• update counters
• decide
- std. update
- archive update
- gain change (ACC)
- learnouts
If AAT on this frame
Automatic Adaptive Thresholds
804
• variance metric in zones
• non-linear map of detection thresholds
Update Frame Analysis Data
806
• motion
Update Motion Reference
808
• copy B to A
{to save FPGA data}

Figure 42

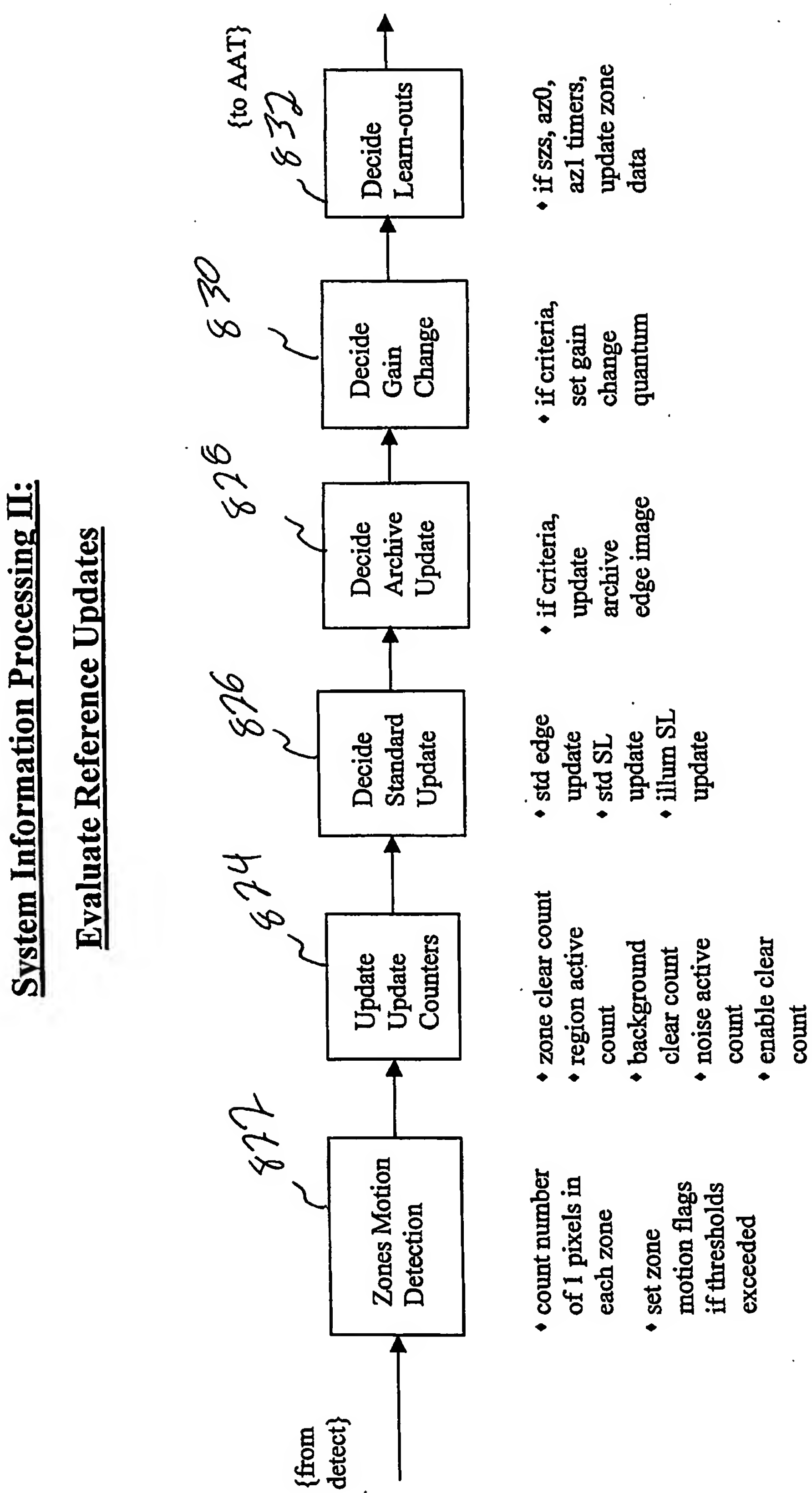

System Information Processing II:
Evaluate Reference Updates
{from detect}
Zones Motion Detection
822
• count number of 1 pixels in each zone
• set zone motion flags if thresholds exceeded
Update Update Counters
824
• zone clear count
• region active count
• background clear count
• noise active count
• enable clear count
Decide Standard Update
826
• std edge update
• std SL update
• illum SL update
Decide Archive Update
828
• if criteria, update archive edge image
Decide Gain Change
830
• if criteria, set gain change quantum
Decide Learn-outs
832
• if szs, az0, az1 timers, update zone data
{to AAT}

Figure 43

System Information Processing III:

Automatic Adaptive Thresholds

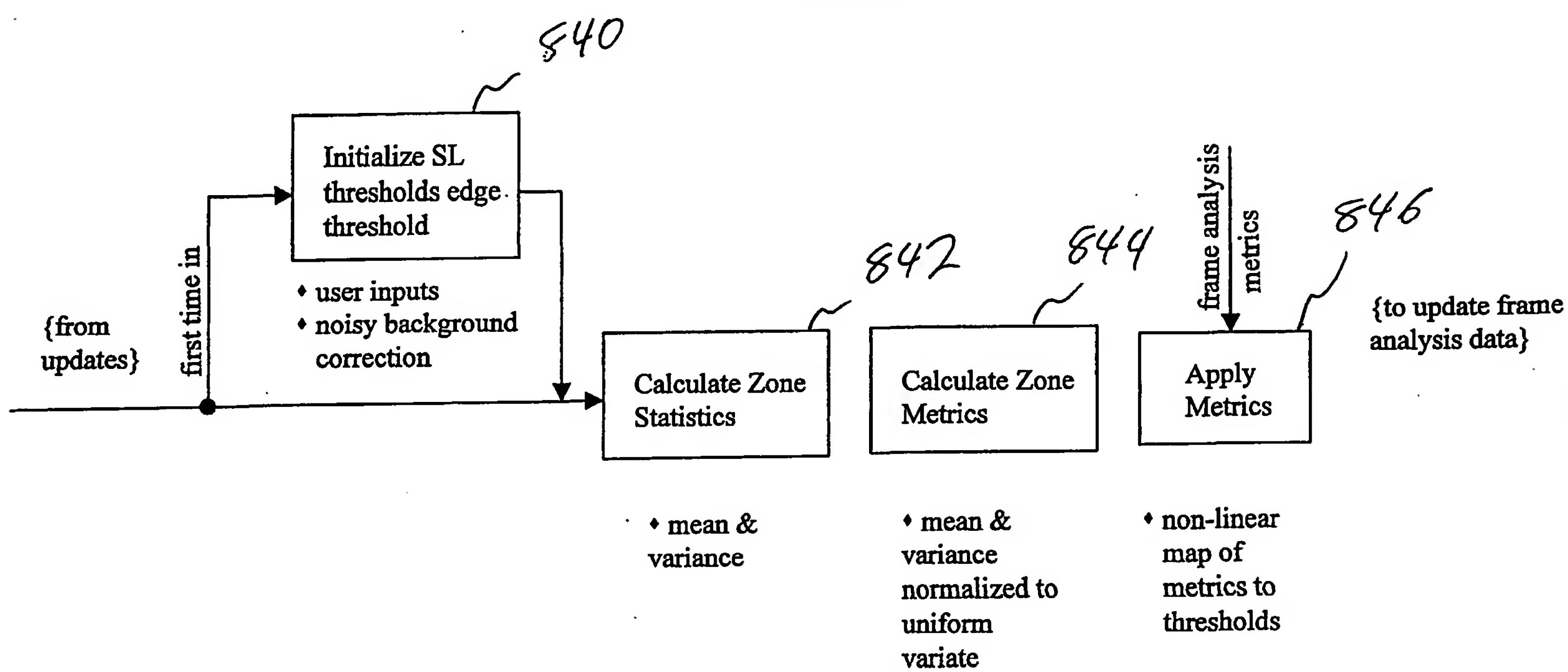


Figure 44

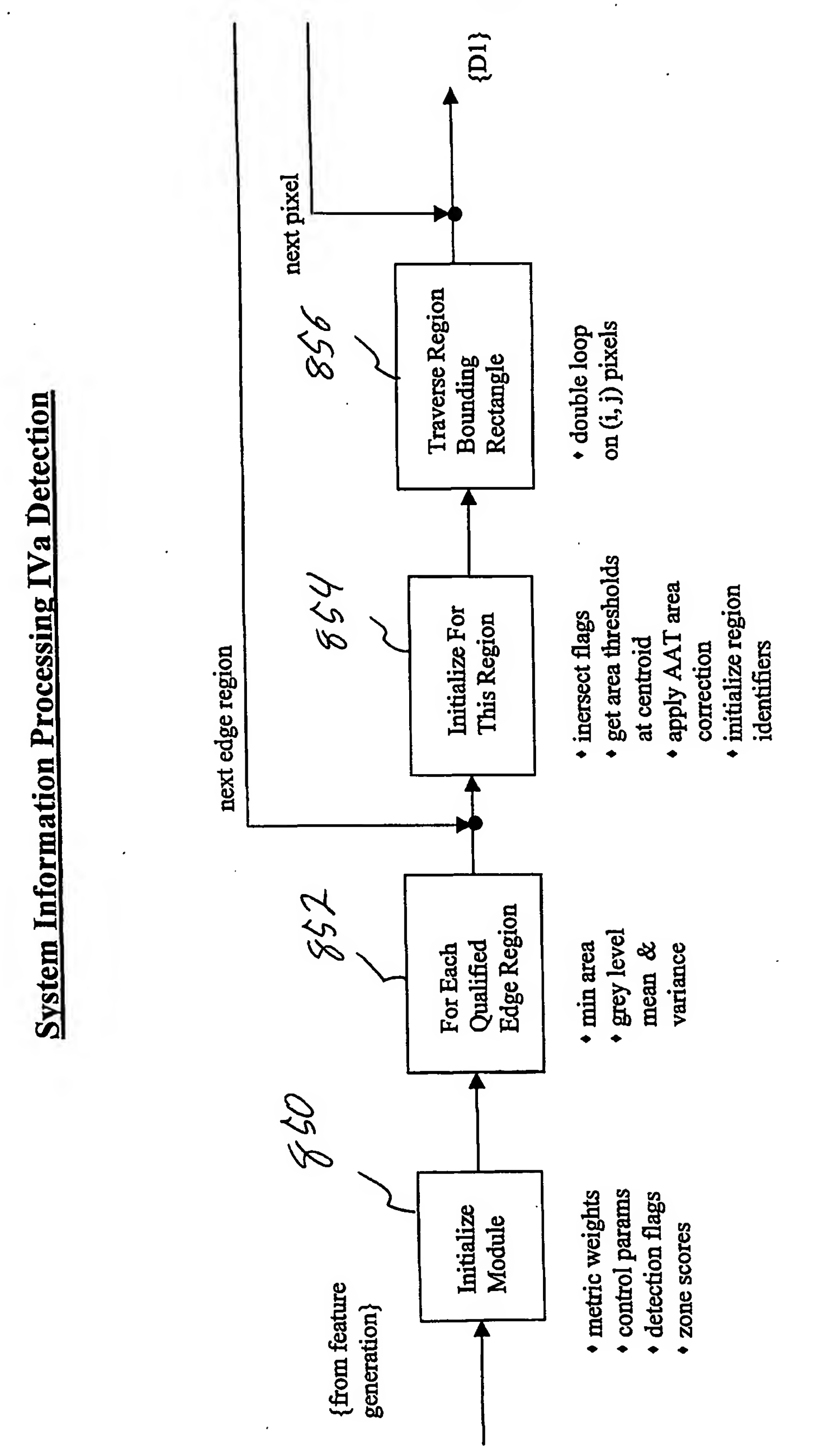

System Information Processing IVa Detection
{from feature generation}
850
Initialize Module
• metric weights
• control params
• detection flags
• zone scores
852
For Each Qualified Edge Region
• min area
• grey level mean & variance
next edge region
854
Initialize For This Region
• inersect flags
• get area thresholds at centroid
• apply AAT area correction
• initialize region identifiers
856
Traverse Region Bounding Rectangle
• double loop on (i, j) pixels
next pixel
{D1}

Figure 45

System Information Processing IVb Detection

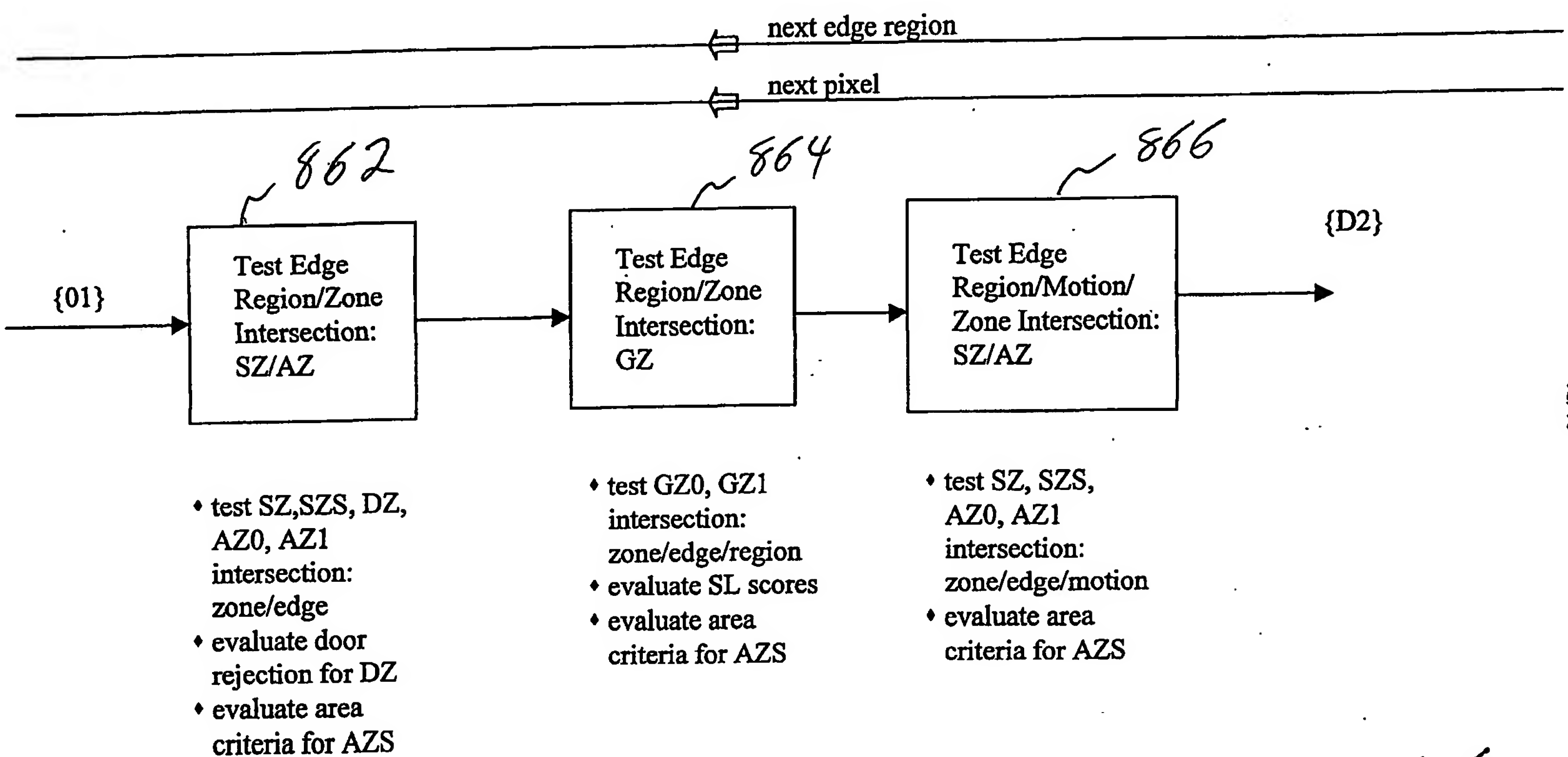


Figure 46

System Information Processing IVc

Detection

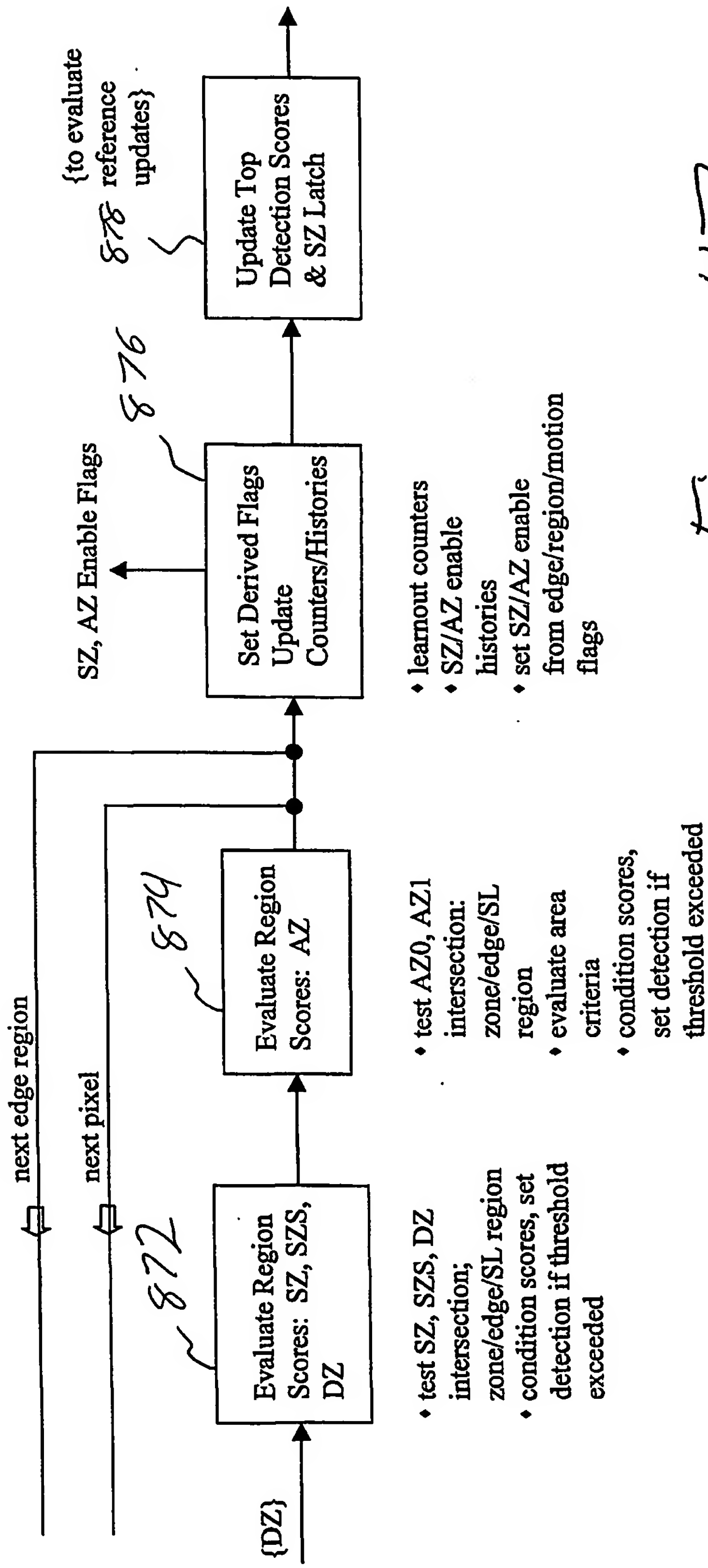


Figure 47

Image Operator Definitions

(-) **Positive difference (of two grey-scale (8-bit) images)**

Pij – Qij = Pij – Qif if Pij > Qij
= 0, otherwise.

+ **pixel-wise (bit-wise) (inclusive) logical OR (of two binary images)**

T **threshold (an 8-bit image)**

If Pij > THRES then
Pij = 1
Else
Pij = 0

IT **Invert/threshold**

Pij = 255 – Pij
If Pij > THRES then
Pij = 1
Else
Pij = 0

E **binary erosion, 3x3**

3x3 kernel Ke

1	1	1
1	C	1
1	1	1

if center = 0, do nothing, next kernel position
if center = 1 {black} then test to see if should change to white...
if sum of 8 neighbors <= 4, set center = 0

set image boundary to 0

D **binary dilation, 3x3**

3x3 kernel Kd

1	1	1
1	C	1
1	1	1

if center = 1, do nothing, next kernel position
if center = 0 {white} then test to see if should change to black...
if sum of 8 neighbors >= 4, set center = 1

Figure 48

set image boundary to 0

S Sobel edge operator, 3x3, (sum absolute values, amplitude only)

Convolve input image with standard Sobel 3x3 (horizontal & vertical) kernels Ksh, Ksv producing inner products h & v respectively

Ksh

1	2	1
0	0	0
-1	-2	-1

Ksv

-1	0	1
-2	0	2
-1	0	1

Outputij = abs(h) + abs(v)

set image boundary to 0

AD absolute deviation, 3x3

3x3 kernel Kad

1	1	1
1	x	1
1	1	1

Calculate Mk & Sk on the kernel (8 elements)

Mk = right shift 3 bits (sum Pij on Kad)
Sk = right shift 3 bits (sum abs(Pij – Mk) on Kad)

Outputij = Sk

set image boundary to 1

A0 region labeling, first pass
2x2 kernel Ka0 over binary image per attached C-code segment

Figure 49

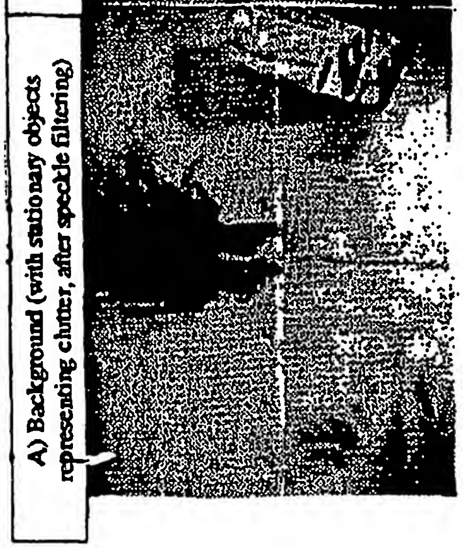


Figure 50

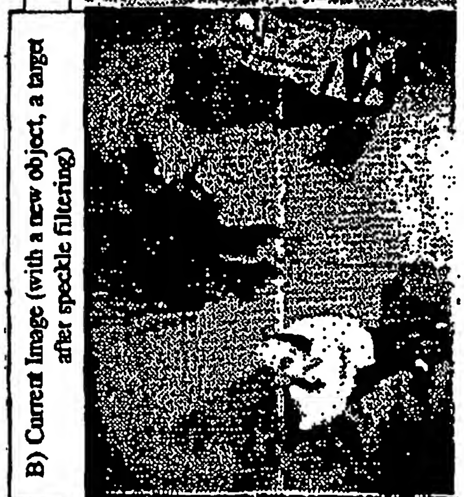


Figure 51

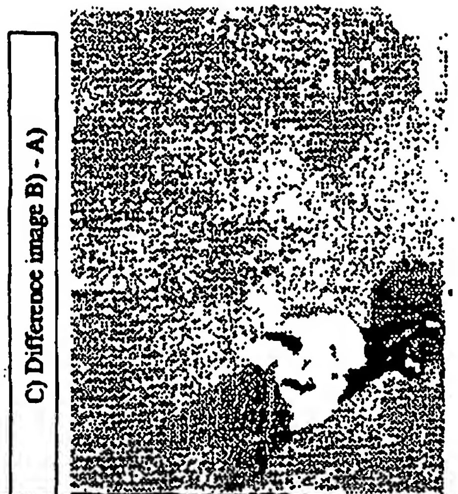


Figure 52

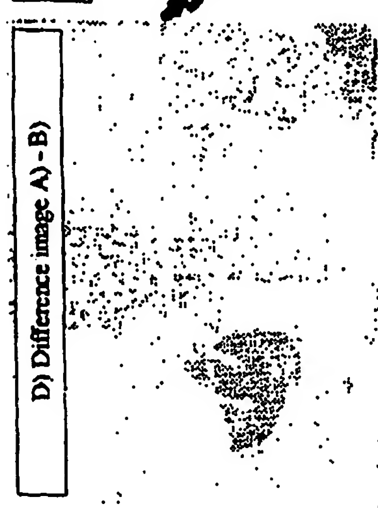


Figure 53

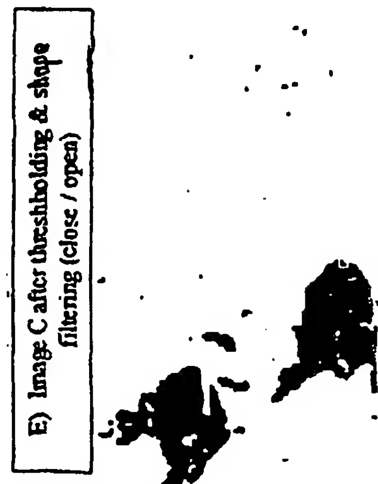


Figure 54

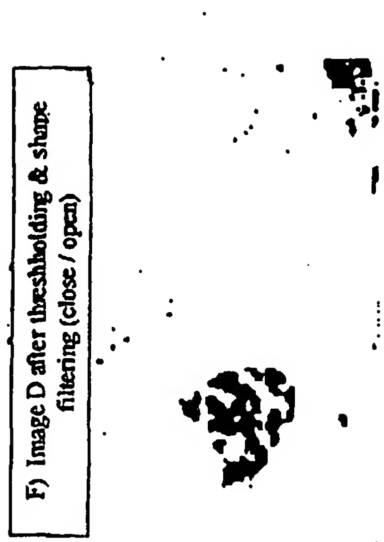


Figure 55

G) Logical OR combination of images E & F

Figure 56

H) Same as G, but with connected region labeled for classification

Figure 57